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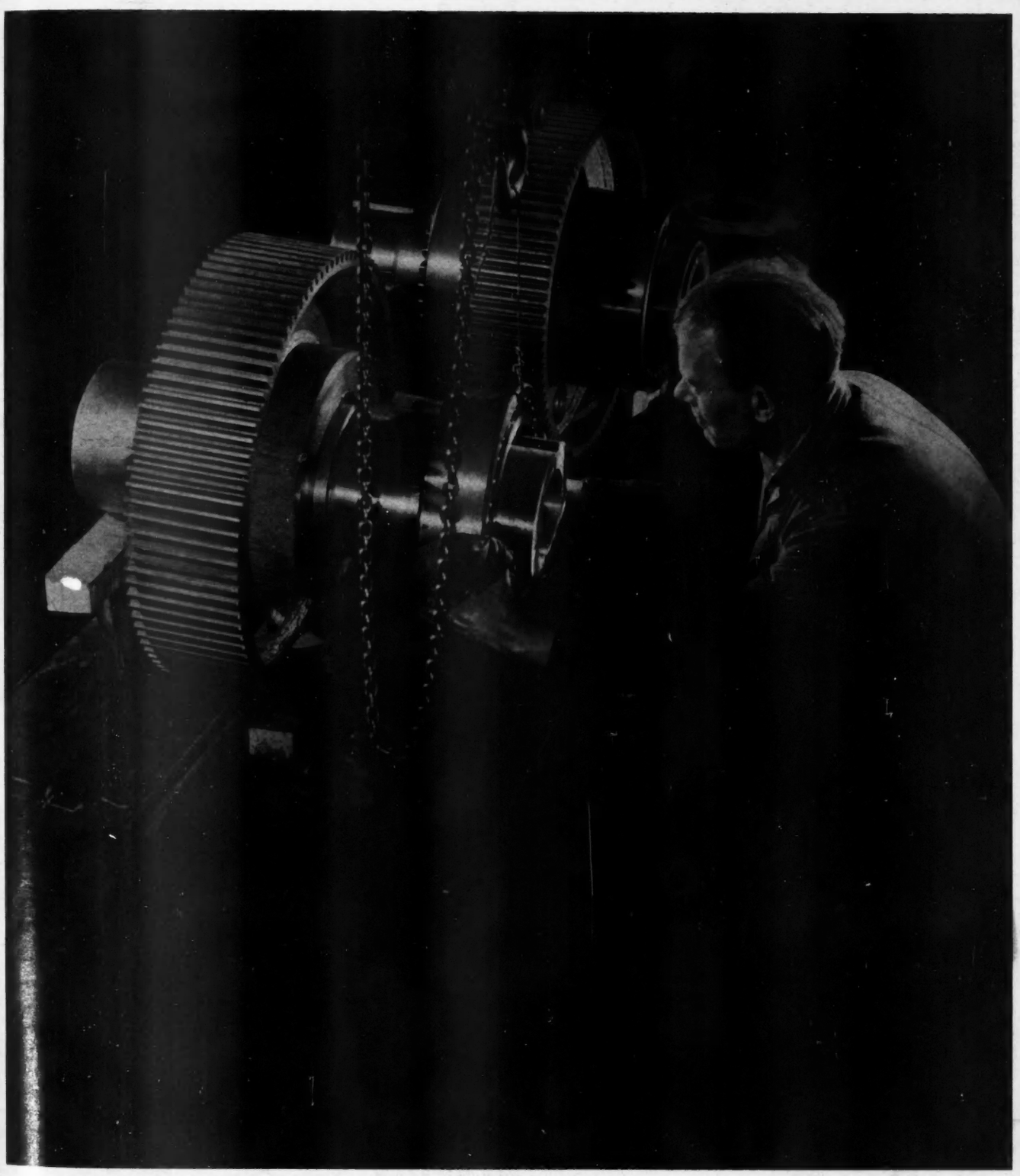

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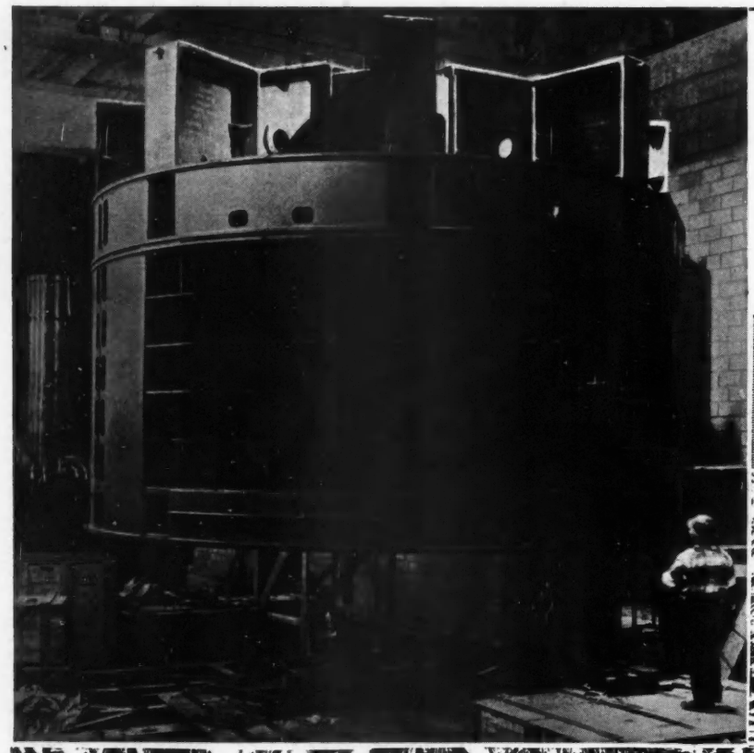
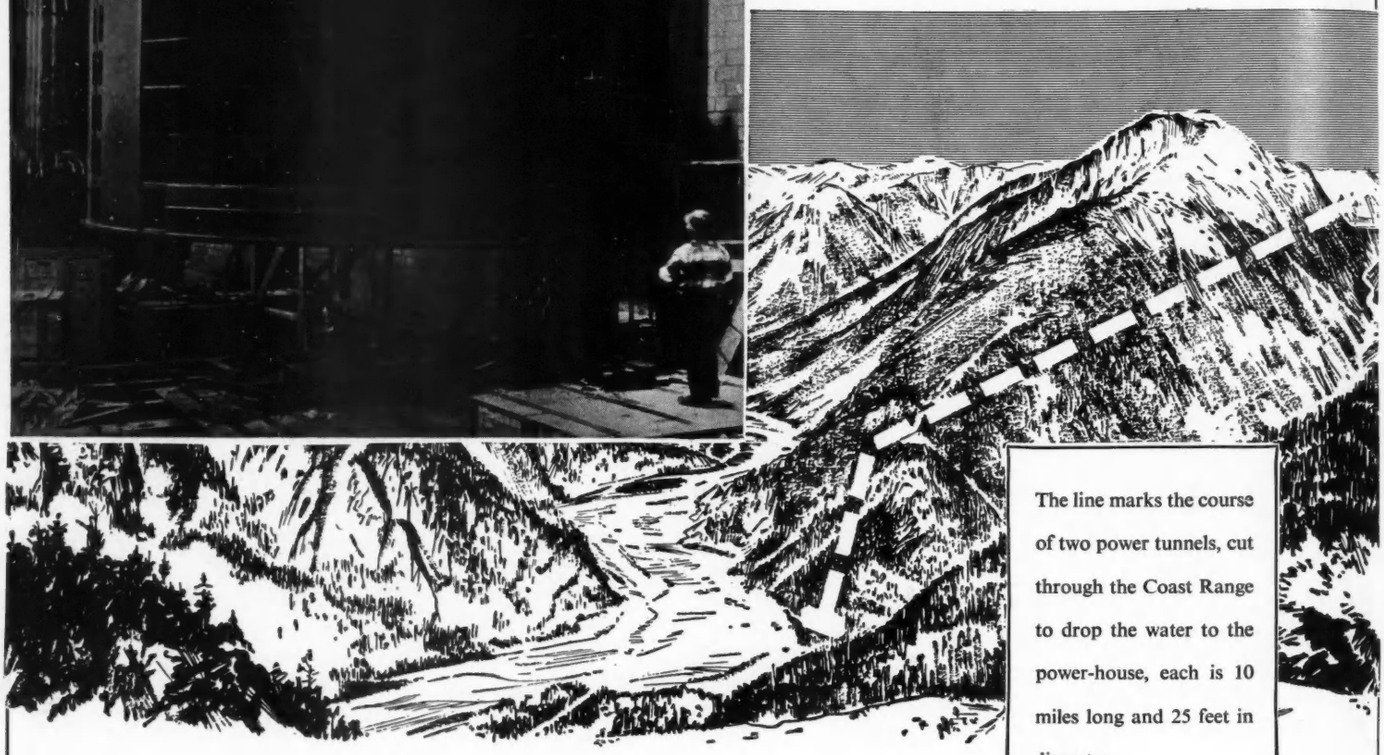


A POWER HOUSE IN A MOUNTAIN



The line marks the course of two power tunnels, cut through the Coast Range to drop the water to the power-house, each is 10 miles long and 25 feet in diameter.

The Kitimat project of the Aluminium Company of Canada plans eventually for an annual production of 500,000 metric tons of aluminium, requiring electrical power equivalent to 1,650,000 h.p. The initial stage of this scheme, comprising 450,000 h.p. is completed. The ENGLISH ELECTRIC Company's contribution to this first stage is a 105,000 kVA alternator. This is one of the largest water-turbine-driven alternators built in Great Britain, and was delivered well ahead of schedule.

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Vol. 180 No. 4690 DECEMBER 16, 1955

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REVOLT AGAINST NOISE

It is a mark of civilised society that its upper social and intellectual crust revolts against noise. In this country the revolt has gathered momentum in recent years, spurred on by deep-felt objections to the nuisance of flying operations, and there is now a growing demand for positive national action similar to that which has been taken to achieve cleaner air. Because of the technical difficulties of measuring the nuisance value of noise it is unlikely that an Abatement of Noise Act will reach the Statute book. But the failure to obtain peace and quiet by Act of Parliament will not lead to the struggle being abandoned; it is more likely to result in an increase in the pressure and protest which can be brought to bear on anyone who can be regarded as a sinner. Engineers are high up on the list of sinners; but they are not hardened sinners, for most of them agree that unwanted noise is a curse of modern life. There is a market for quiet machines.

The raw material for several novels awaits the pen (or silent typewriter?) of a Dickens of this century. If poverty is not as harsh and widespread as it was in Dickens's day, the assault of noise on the brain, and on the individual's capacity for concentration, has become intolerable. In the home, in the street, in the workshop, in the office, and even in the club, the agencies of publicity, official exhortation and unofficial amusement all compete like fairground side-shows to entice the hapless man who has his own ideas of what he wants to see and hear. Unfortunately for him the approach is usually a thinly disguised temptation to one or other of his primitive instincts, and although he may succeed in building up his resistance, even to such a degree that he can manfully leave the fairground, it is only to find that other and more subtle vamps are waiting for him round the corner. The only hope left for him is to participate directly in the process—choosing, perhaps, the more elegant and refined techniques—and thus become so cynical of the whole artificial set-up that he is impervious to all the blandishments that strew his path. We offer this tragic theme, without charge but for the general good of society (thereby, of course, participating in the ghastly process ourselves) to any novelist or dramatist who likes to work on it, though we would appreciate an autographed copy of the book or a complimentary ticket for the first night.

When the House of Commons, a fortnight ago, debated " the detrimental effect of noise and vibration on the health, wellbeing and efficiency of the nation," it had to adjourn after four hours because less than 40 Members were found to be present. But that should not be taken as a sign that the subject is not worth examining. It is only those M.P.'s who receive complaints about aerodromes who are obliged to act. Hence the sparse attendance during the debate. In addition, the debate took place on a Friday afternoon, and it was not the kind of topic that causes a sharp division between the Government and the Opposition.

For the mass of people noise is not a special nuisance; it may even constitute a friendly element in their environment, as town-dwellers have discovered when they stayed in the country. But it is worth noting that the planners of towns and factories, and in general everyone who is responsible for selecting and ordering plant and equipment, has a civilised aversion to unwelcome sounds. They tend to be members of the intellectual crust, because they are professional or business men, and they would therefore be attracted by a design which, other things being equal, was quieter than its competitors. This fact alone may be sufficient argument in the case of many products for devoting some effort to noise reduction when working out a design. Motor transport comes in for a good deal of criticism; it has been suggested that electric trolley buses should not be replaced by Diesel-engined vehicles. Sports cars are common offenders, though at least one British model is almost as quiet as a high-class saloon car. Motor cycles, " mopeds " and the like are hated nearly as much as low-flying jet aircraft. Air compressors and pneumatic road drills are common targets for criticism. In certain areas drop hammers are the chief offenders, and in others such processes as riveting and sawing are unwelcome intruders.

Although sound and hearing are largely subjective experiences, and therefore a difficult subject to legislate for, enough is already known to facilitate a substantial lessening of the noise caused by the products of engineering. As reported elsewhere in this issue, the National Physical Laboratory will shortly be publishing the results of four years work on the relation between the intensity of sound (an objective, measurable property) and its loudness to the human ear (a subjective not-so-easily-measured property) Research has also been carried out in other establishments and in the universities, as well as in the United States and some Continental countries. A lead has been given by several aero-engine firms in this country. Other firms, in other branches of engineering, may find it profitable to explore the possibilities with their products, and companies which make sound-reducing components have a new opportunity. Quietness of operation may be a big selling point for those who can offer it first.

Weekly Survey

Cover Picture: *The severe working conditions to which rolling mills are subject give rise to special problems of design and manufacture. Bearings and gear teeth, in particular, must be capable of withstanding heavy fluctuating loads and, being exposed to shock loading, must be kept free from superficial damage; considerable care must therefore be taken during assembly. The fitter shown in the illustration is assembling roller bearings on the reduction gear shaft of a blooming-mill breast-roller drive.*

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Crystal Gazing without Tears

Avoiding economic depressions is partly a question of being forewarned. Economists have been trying for long enough to formulate some way of forecasting how industrial activity will move in the future. During and after the war, a whole host of intricate statistical methods were evolved which attempted to solve the problems of business forecasting. The national income method of accounting was developed, indices of industrial production, employment figures and the like were improved and rationalised, and new figures such as the index of gross domestic capital formation evolved. Input-output tables are the most recent addition to the national income statistics and at present the Government are circulating businessmen to find out their investment intentions.

Statistical data, however, suffer from one big disadvantage: their value as a business activity indicator, albeit excellent in showing what has actually happened, is severely limited by the fact that by the time the figures are published many of them are out of date. The index of industrial production is always two months in arrears; at the other end of the scale the latest input-output table is for 1951. Some quick method is obviously needed whereby industry and the Government can know immediately what is going on and what is likely to happen. The latest issue of the Economic Bulletin for Europe published by E.C.E. describes a method which attempts to do something towards solving this problem. The new method is called the "Konjunkturtest," the name given to a sample survey of business firms on their appreciation of trends and prospects. Statistics are dispensed with and firms are merely asked to say whether their output has gone up or down or has remained stationary. The method has been used widely on the Continent and can be a valuable contribution to businessmen and economists in forecasting business activity. It has the advantages of quickness and "on the spot" information and, used wisely, does away with the need to complete complicated forms which in some instances may make statistical returns unreliable, and are always tedious to fill in. It is obvious that questionnaires should be as brief, simple and comprehensive as possible, for the businessman has no taste for complex definitions and less time to try to understand and answer them. The Konjunkturtest, coupled with simple and regular questionnaires, offers a quick additional tool in forming and keeping up-to-date forecasts of business trends a few months ahead. The word "additional" should be emphasised for the method is no substitute for accurate statistical work.

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Germany Examined

In 1955, the gross national product of Germany is expected to have increased by about 10 per cent. (allowing for changes in prices) while industrial production is likely to have increased by 14 to 15 per cent. This is double the rate of expansion in this country. Germany also had a substantial increase in its reserves of gold and dollars in the first half of the year and it is expected that the reserves will go on rising throughout this year. These facts have been disclosed in a report on economic conditions in Germany which is one of a series on Western European countries put out by the Organisation for European Economic Co-operation.

Some of the background of this remarkable recovery from disorganisation and destruction is mentioned in *A Brief Review of Science and Technology in Western Germany*, reviewed on page 817 of this issue. Some interesting comment is made there on the value to enterprising managements of the removal by Allied bombing of inefficient companies, and the amount of information on competitors which allied investigating teams indirectly presented to other concerns. The O.E.E.C. report sets out quite clearly the rewards in terms of rising output and higher productivity of German discipline, abstinence, and hard work.

The rapid expansion of production in recent years has been facilitated by the availability of labour. Western Germany has now reached the stage of full employment, a state of affairs which coincides with the creation of the new German Army. The need for further manpower to increase output without creating inflation thus coincides with a drain on available manpower resources into the armed services. On the whole, the report is inclined to the view that German re-armament, measured either in terms of a drain on manpower, or demands for service equipment, will be met without inflation, although there may be a slackening in the rate of increase of civilian industrial output. It has to be remembered also that the existence of an export surplus provides a reserve which can be drawn upon by industry at home, say, to increase capital investment, although this reserve has already been slightly mortgaged by higher imports. It has been official German policy to further liberalise imports as a means of mopping up purchasing power. If a rising proportion of Germany's resources are used for capital investment as a means of raising productivity in a time of full employment, there is the danger that increasingly severe pressure will be brought to bear on the supply of consumer goods. Increased defence expenditure would have the same effect. In 1956, it should be possible to find out if Germany is to join the majority of members of O.E.E.C. as a fellow-sufferer with the fashionable complaint of inflation.

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Expansion of Compression

Atlas Copco, as the Swedish Atlas Diesel organisation will be called from January 1, 1956, has enjoyed a remarkable increase in its business since the war. Between 1948 and 1955, the volume of output per man-year increased by 30 per cent. There must be many companies which can produce a better figure than this but very few of them can do it so quickly after taking as critical a decision as Atlas did.

For many years the organisation made Diesel engines and compressed air equipment. Owing to the shortage of labour in Sweden after the war, the company had to make up its mind to abandon one of these and it decided to stop production of Diesels. It considered that there was a big enough future in compressed air in an age of scarce labour (from the equation that unskilled labour plus robust tools equals high output) to justify the decision. So Atlas went for compressed air tools and planned its strategy on a large design team and mass production, which meant going for export markets. Sales exceeded expectation and between 1946 and 1955 export turnover went up from one third to three quarters of the total business booked. Factories had to be found at home and abroad. There are now five factories in Sweden and plants also in England, South Africa, Canada and Finland. In Sweden labour is still a problem, and men have been brought from Italy. Parts have been imported from Germany and Spain, and may soon come from other sources including this country.

The company credits international airlines as a major factor in helping to set up rapidly a world-wide export organisation. To-day 35 per cent. of the company's capital is invested in the British Commonwealth and the sales director in Stockholm is a Canadian. Since 1946, the group has grown from three to 26 overseas companies. Here is an interesting case history of a concern that had the imagination to break with its own tradition (it had made Diesels since 1898) and throw its energies exclusively into a field which careful analysis of broad industrial trends indicated had a big future.

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Shipyards for the Bahamas

The Bahamas, not usually associated with industry in any sense of the word, should attract new enterprise and perhaps a crop of sociological problems when recent plans announced by the Governor, The Earl of Ranfurly, come to fruition. Freeport, an aptly named new industrial area created by the Bahaman Legislature in August this year, will soon start construction work on its first major project—a shipyard costing £12 million "for the construction, repair and scrapping of ships and all or any businesses and trades which are both subsidiary to or necessary in connection with the operation of such a shipyard." Plans were also disclosed for a chemical lime plant with an annual capacity of at least 100,000 tons.

Both projects are being undertaken by the D. K. Ludwig interests. Bahama Chemicals, Limited, have also been granted a licence to export lime rock, which is of particularly high quality in this area. Bahama Shipyards, Limited, have interested four large U.S. super-tanker concerns who have pioneered in this type of tanker construction. These are National Bulk Carriers Incorporated, American Tankers Corporation of Delaware, Seatankers Incorporated, and Universe Tankships Incorporated. Incentives for these companies to develop in the area are certainly attractive, for concerns operating in Freeport will be free of all taxation for at least 30 years, and will have to pay neither import nor export taxes on stores and equipment for 99 years. Approximately 50,000 acres have been set aside for development, and manufacturers can bring in their labour from anywhere.

The new shipyard will be built to take ships from 20,000 to 80,000 tons deadweight, and the largest slipway is expected to be 1,200 ft. in length and 200 ft. wide, and will thus accommodate the largest vessels. Two basins will be constructed and provision is made for a third to be built later. The harbour, which will be dredged by Bahamas Shipyards Limited, will have a 250 ft. wide channel and a land-locked turning basin of at least 1,000 sq. ft., while dredging will be carried out to a depth of 32 ft. at mean low water. It is expected that the whole project will be completed within the next two years.

With world trade in oil growing, there is little doubt that this announcement will be welcomed by oil concerns and tanker interests alike. Shipbuilders in the U.K., for example, have recently criticised the inadequacy of British yards to take large tankers for repair, and the few Continental yards which can take large ships are overcrowded and overworked. The Bahamas are placed strategically between the Venezuelan oilfields, the growing Texan reserves and the markets of New England and Western Europe.

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Courses for Electrical Technicians

The main objects of a conference which was held at the Institution of Electrical Engineers under the chairmanship of the President (Sir George Nelson, Bart.) on December 2, were to publicise a scheme for the conduct of examinations for electrical technicians and to discuss a report commenting on some of the proposals that have been made to this end. This was the third conference to be convened by the Institution during the past two years to consider the

need for more courses to meet the requirements of that large body of workers in the industry for whom the existing craft and National Certificate courses are unsuitable. The scheme now suggested offers courses leading to a Technicians Certificate to those engaged in the design, manufacture, erection, operation and maintenance of electrical plant and equipment. Initially these courses will cover plant and machinery; power generation and supply; and industrial electronics, but additions will later be made and, in particular, early attention will be given to one for electrical drawing office technicians. Each course will last four years and is intended for students attending part-time day classes on one day or on three evenings a week.

During the first two years the subjects will include electrical engineering principles, engineering materials and drawing, practical mathematics and technical reports. In the third and fourth years the special requirements of those employed on power equipment and industrial electronics will be catered for. During the fourth year, too, provision will be made for colleges to develop courses and examinations to meet local requirements. The Electrical Technicians Certificate will be endorsed by the Institution of Electrical Engineers, the City and Guilds of London Institute and, when appropriate, by an association concerned with technicians. A full Technological Certificate will be awarded to those who subsequently obtain passes in at least two " endorsement " subjects and will be endorsed by the Ministry of Education. Warm support for the new scheme has already been given both by industry and the technical colleges.

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Colombo Looks Ahead

There are signs that the Colombo Plan organisation is beginning to accumulate valuable experience for the future from its four years of activity to date. This is apparent from the fourth annual report of the Consultative Committee for Co-operative Economic Development in South and South-East Asia (usually referred to as the Colombo Plan organisation), which was published recently.

A number of basic points have emerged. First, recent experience has brought out the wide differences in the economic situations of the different countries benefiting under the plan, even in a time of world prosperity. Second, while considerable progress has been made so far, the tasks ahead are becoming bigger and more complicated. This is in a sense the inevitable price of success in the early stages, for the bigger and more ambitious the plan becomes the more is expected of it and the more complicated becomes its organisation. Third, the mobilisation of domestic capital is of paramount importance. Lastly, there are many common economic problems calling for a regional as opposed to a national approach. Already, some of these countries have begun to find that by the flexible use of fiscal devices such as credit control and export levies it is possible to offset the complication which arises in planning development over a period of years when exports (and correspondingly imports) fluctuate in response to changing world market conditions. The degree to which countries have been able to organise their development plans has varied considerably. For example, some countries have concentrated on special projects and others have begun by carrying out surveys of basic resources. The report makes the important point that so far improvements have been achieved to a large extent by mobilising more efficiently existing resources. From now on greater emphasis will be placed on obtaining fresh resources. This, of course, puts a bigger strain on the Colombo organisation, but it must also mean an increased opportunity for those countries which have technical expertise and equipment to sell.

So far this exercise in economic co-operation in South-East Asia has been remarkably successful, not least because it began modestly with a simple streamlined administration unit.

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Stewarts and Lloyds

Stewarts and Lloyds' financial year ended October 1, 1955, provides a complete year's operation since the denationalisation of the company. The consolidated trading profit for the group has increased over the year by 9 per cent., which is perhaps rather less than had been generally expected. The full report on the financial year will not be available until January but the company has divulged a certain amount of information about its results in its dividend announcement. The increase in the company's own earnings is given as 5 per cent. and that in the home subsidiaries as 7 per cent. Since this increase has been on an increase in the tonnage of steel tubes of 12 per cent., profit margins must have been reduced. On the whole this seems likely to have been due to the failure of prices to increase rather than to a notable upward pressure in cost. It has to be remembered that under the present system of periodic price reviews for steel in the home market, steel prices are apt to move infrequently and jerkily.

In contrast to the home companies the overseas companies and trade investments showed an increase in profits of 32 per cent., while the volume of spun iron pipes and castings from such companies to general customers increased by 15 per cent. and the corresponding tube tonnage (other than tube exports to oil companies) by 7½ per cent. Meanwhile the expansion of capacity in this country is recorded in the accounts over the last financial year as having added £4·6 million to gross fixed assets. Broadly speaking, exports provide Stewarts and Lloyds with their most profitable business. Apart from one other large group, Tube Investments Limited, Stewarts and Lloyds own most of the steel tube capacity in this country. The company is well established in both seamless and welded tubing. Since almost half the total output of tubing in the United Kingdom is seamless and a very high proportion of this goes to oil producing countries, Stewarts and Lloyds are particularly dependent on the prosperity of the oil industry for much of their turnover. It has in fact been the prosperity of the oil industry which has brought about such a remarkable recovery in the prospects of the company's Scottish works in the last ten years. With the prospects of continued prosperity for the oil industry, and the very heavy drilling programme which is now undertaken from year to year in North America to open up new and deeper oil reserves, the prospects for the company remain bright so far as seamless tubing is concerned. The growing acceptance of E.R.W. tubing for an increasingly wide range of pressures is also a pointer to continued success for the company's works specialising in these kind of tubes.

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Industrial Effort in Italy

Recent figures suggest that, on the face of it, the Vanoni ten-year plan for Italy (described in ENGINEERING, July 1, page 2) has got away to a good start. The aims of the plan are broadly three-fold—to create 4 million new jobs, to establish more new industry in Southern Italy and to increase invisible exports. It is aimed to achieve these goals by £21·5 million of investment (of which £5 million is to come from private sources), liberalisation of trade to attract foreign capital and redeployment of the growing labour force so that the dependence of the South on agriculture is alleviated. It is also assumed that the national income will be increased by at least 5 per cent. per annum.

As the first year of the plan draws to its close, the figures are, at first sight, encouraging. The national income is estimated to have increased by 7 per cent. in 1955, industrial production has risen by 11 per cent., the harvest everywhere has been excellent and oil has been struck in several places. Employment had risen from 17·5 million in May, 1954, to 18·2 million by November, 1955, which suggests that after allowing for a natural increase in the working population, 169,000 previously unemployed have been absorbed. Investment is estimated to have increased by £170 million over the year against the £120 million rise considered necessary.

There are signs, however, that much still needs to be done, and criticism has been levelled at the Italian Government on the grounds that it has done little on its own account to engender economic growth. For example, the overseas trade deficit has widened slightly despite record tourist earnings and a 12 per cent. increase in visible exports. The engineering industry, which has had a good year, depends mainly on motor vehicles and office machinery for its increased production. However, a crisis in the textile industry has affected the output of textile machinery and the machine tool industry has lost ground, while output of railway equipment is below pre-war levels. Also, manufacturers are protesting against the inadequacy of tariff protection for domestic industry. The only significant measure so far introduced by the Government has been the grant of tax concessions to exporters early this year, but there has been neither a marked increase in Government investment nor any particular encouragement to private investors. Governmental economic policy is unco-ordinated and vague. Few outside Italy would raise the oil-refining capacity to its recently scheduled levels. Seen in the general world framework of competition for both export earnings and attracting foreign capital, the Italian Government could well revise its ideas on economic policy, especially on how encouragement to private enterprise is to be reconciled with judicious overall control. Without Government assistance the Vanoni plan could become just another happy dream and inflation the sharp awakening.

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Consultants on Automation

Sir Walter Puckey is chairman of a new firm, Automation Consultants and Associates, Limited, 18 Berkeley-street, London, W.1, which has recently been formed to " provide an advisory, and if required a design, service on automation at home and abroad." The directors include Mr. John A. Sargrove, who in 1944-46 designed what has been described as the first automatic factory —a plant for making electronic circuits consisting of valve sockets, condensers, inductances, resistors, and linking conductors by the spray-milling technique of metal and graphite deposition. The plant automatically inspects each operation as well as the final product, and in this sense is a " conscious " machine.

The firm believe that automation must be regarded, not as a one-sided technology, but as a problem calling for a balanced approach and solution. They aim to serve public and private organisations, banks, finance houses, trade and research associations, trade unions, social groups and foundations, educational establishments, and other groups of consultants and consulting engineers. In design, production, administration, marketing and human relations they plan to give advice on a subject which is not generally understood, even among engineers.

There is undoubtedly tremendous scope for such a firm, even in industries and organisations where mass production is not a dominant feature. No one can fully appreciate the possibilities of automation until they have analysed those possibilities in their own field. It therefore requires an act of faith, a leap of the imagination, before the initial step of inquiry can be taken. It may be asked: " What is automation?" To this Sir Walter replies " Automation = machine power + control power." Machine power is well understood; control power only imperfectly. An explanation of the scope for control power is required if automation is to be taken seriously in this country. Those engineers who already understand it are not likely to hesitate.

THE FARMER'S APPROACH TO MECHANISATION HAS CHANGED

By John J. Coady, M.SC. (AGRIC. ENG.)*

A journey through any of our rural and essentially arable counties during a busy farming season cannot fail to bring home to the keen observer the extent to which British agriculture has become mechanised. Gone are the picturesque scenes of horse teams on the skyline, the whistle of the ploughman and the creak of warm harness. The picture is now one of gaily coloured tractors passing hurriedly to and fro, while the peace is shattered by the strident notes of hard working engines. This visual impression, however, is merely the outward sign of more fundamental changes which have altered the character and economic pattern of agriculture.

Statisticians have no difficulty in pointing out the increase which has occurred in the tractor population; of how their number has been multiplied by eight since pre-war days so that to-day there are over 400,000. Other machinery has increased to match, and equipment numbered in thousands exists to-day that was not even recorded in Ministry census figures a few years ago. The economist, too, can easily be found who views the capital expenditure and high maintenance costs with horror. It is true that over £50 million was spent on new equipment last year, and arguments are often arrayed which seek to prove the folly of the industry burdening itself with such "uneconomic" machinery. The popular cry is that agriculture is over-mechanised, that capital invested in equipment would be far better used in some other way, and that in any case the machines already in existence are not being used to the best advantage. But all these are generalisations. There are reasons why this country is so highly mechanised. This huge machinery force has not all been acquired without thought, and the high level of production could certainly not have been achieved without its aid.

LABOUR SCARCE

The drift of workers from the land unfortunately continues; there are 50,000 fewer than in 1951. At the same time the wages of those that remain rose to over £270 million in 1953-54. Labour is now the most expensive item of production used on farms, accounting for 28 per cent. of total outgoings. But despite this depletion in manpower, production has steadily increased to within sight of the "60 per cent. plus" target (above the 1939 level) fixed by the Government. It must also be realised that each increment of production is successively more difficult to obtain. As marginal land is reclaimed, there remains the super-marginal and more difficult terrain above, to be won at even higher cost. And in the lowlands traditional farm land is lost to new townships and roads.

When labour becomes scarce or expensive, the use of machinery is encouraged. Machinery enables a man to perform more useful work than he could do without such aids; it enables him to work often without fatigue; correct timing according to weather conditions can be achieved, and it enables a farmer to be almost independent of seasonal or casual labour, the supply of which is often unreliable when the need is vital. Superimposed on the purely economic considerations there is the influence which farm size has upon the number of tractors and machines in use. Over 80 per cent. are family farms of under 100 acres, while only 7 per cent. are larger than 300 acres. Machinery enables the small farmer to increase the intensity and scope of production on his limited acreage to a high degree. It enables the same staff—the family—to reach limits impossible by manual means. But the fact remains that a farm of 100 acres requires almost as much equipment as one of twice that size, and tractors are not to be bought in divisible units precisely graded so that they can be selected according to farm size. Equipment is not always used to the maximum extent of which it is capable, but in its season each item has an important role to play.

RESERVE OF POWER

On large farms large-scale production may be possible in areas where labour is scarce. There are no longer the men and women capable of harvesting the cereal crop sheaf by sheaf, or of bringing home hay in loose and light loads on a wain. Even on large farms an old tractor, long since retired by the accountant, may stand idle for eleven months of the year. It may serve as a vital reserve in case of breakdown, or in a short and busy season its power may complete a mechanised programme. There must be many such old tractors listed in the statistics, still pointed to by mathematical analysts as examples of over-mechanisation.

Unlike the horse the modern tractor is not merely a power unit to provide haulage. It is required to carry implements on its rear hydraulic linkage, between its wheels, or sometimes as a complicated surrounding envelope of chains and gears. It may be needed to feed part of its power into other machines, to generate oil under pressure, or to become a mobile power station fulfilling a variety of purposes. As the tractor has developed so has the ancillary equipment to utilise fully its power and employ its advantages with greater ingenuity. Such development has taken place in the light of modern agricultural research and as new farming techniques have led progressively to better methods. There are usually many ways of performing the same agricultural process and they can often be mechanised to varying degrees according to the supply of labour, the availability of capital, and the dictates of crop and circumstance. It is therefore open to each farmer to decide what particular technique best meets his need. He is not, however, or should not be, unaided in making this decision. During recent years, the surveys of university agricultural economic units, Government advisory services and research institutes have provided a wealth of material to illustrate national trends and point to costs of production, in terms of land, labour and capital of almost every item of farm produce. Guided by such valuable information a farmer can assess the increased production and can compare the expected savings with the costs involved by the alteration of some technique or the adoption of a new method.

Haymaking, for example, is still carried out in the traditional manner in many parts of the country and no doubt will continue in this way for years to come. But it is a typical process which can be speeded up, in some cases with the expenditure of very little capital. It has been shown that when hay is loaded loose on to a wagon the average rate in a particular survey was at 0·4 ton per man-hour. An inexpensive hay sweep mounted on the front of a tractor speeded up the rate of collection to 1·6 tons per man-hour, and enabled the hay to be swept to stack or elevator in the field. The final stage of mechanisation can be obtained by the use of a pick-up baler. Such a machine not only increases the rate of collection to 2·6 tons per man-hour, it also delivers the hay into neat compact bales which can be carried and stacked with ease, and which lend themselves to more accurate rationing of livestock in the winter months. Additionally the pick-up baler can be used for baling straw behind the combine harvester, and has even been shown to be suitable for assisting in silage conservation.

Other techniques are completely new and speed and labour supply do not affect the decision as to their use. Weed and pest control by spraying is a typical example. The latest machinery census indicated the existence of over 18,000 spraying machines, whereas only a few years ago their numbers were not significant. It is, or should be, a rare sight in the spring to see cereal fields a blaze of yellow flowering charlock, or ripening barley blood-red with poppies. Less striking, but equally successful results are obtained in grassland, where the charming but deleterious buttercup may be routed, or in arable crops which can be saved from total destruction by some almost invisible insect pest. An economic report has shown the costs involved in owning and operating a spraying machine. If a crop can be saved, or production over a sufficiently large acreage increased in value to offset the costs involved, then the technique of spraying not only contributes to the improved husbandry of the land, it is also an economic proposition.

SELECTION OF MACHINES

Further evidence is available to justify the purchase of some new piece of farm equipment or the mechanisation of a process. But farm mechanisation as such is far more. It consists in the careful selection of machines, each exactly suited to its purpose, each carefully integrated with other equipment to form a combined mechanical team which can be drawn upon as the farming year progresses and as the crops and climate indicate. Such machinery must not only be carefully selected, it must be efficiently operated and adequately maintained. Until these conditions are fulfilled the maximum benefits offered by mechanisation cannot be achieved.

This is the ideal, and it must be admitted that only in rare cases has it been approached. Machines have been applied to British agriculture in a piece-meal fashion; in most cases they have not been operated with the intelligence and sense of awareness that engineering design demands, and the standard of maintenance is obviously of a low order. The past fifteen years have seen remarkable progress in the science and practice of farming, and it has been difficult for those educated and trained in the horse-plough era to accept readily the principles of petrol and Diesel cycles, or the complex initials of new chemical formulations. But the rising generation of young farmers have been reared on this diet and are wise to the ways of grease gun and spanner. It may be that the modern ploughboy's whistle is drowned by an engine roar and that the carefree days of plodding horse teams are over, but in a world that demands more and more food the picturesque cannot be preserved for its own sake. This new generation has the responsibility and the opportunity to marry the new with the old and so achieve economic, mechanical, and biological harmony, producing an increasing proportion of our food supply as cheaply and as efficiently as possible. Engineers may reasonably look forward to a more co-operative response from farmers.

* Farm machinery officer, National Farmers Union.

* * *

SHAPE OF TRANSONIC AIRCRAFT

The Area Rule and R.A.E.

In September this year news of a new principle, known as the "area rule" and developed by the National Advisory Committee for Aeronautics, for minimising the aircraft drag rise at transonic speed was released by the United States. Very briefly, the rule states that the transonic drag rise is largely a function of the combined cross-sectional area of the wing and the fuselage, and other interference bodies such as the nacelles. We first learnt about it in a communication from the Convair Division of the General Dynamics Corporation, San Diego, who have applied the principle to their F.102A interceptor (ENGINEERING, *September* 23, 1955, *page* 435). *In this application, the fuselage has been "waisted" at*

the intersection with the wings so that the total cross-sectional area is the same as it would be for the streamlined fuselage alone. The spectacular performance improvements claimed to result from this new principle have given rise in this country to questions in the Press and in the House of Commons as to whether British designers are aware of the possible benefits to be gained. To put the matter in its proper perspective, the Ministry of Supply have issued the following statement.

The major credit for the area rule must undoubtedly go to the Americans for their experimental investigations, but quite significant original contributions to its development have been made in Britain, also in Sweden and in France. The area rule is not, moreover, the only method of improving the performance of aircraft at transonic speeds.

Before the news of the American work on the area rule first arrived, some theoretical work on the drag of wing-body combinations had already been made by Mr. W. T. Lord at the Royal Aircraft Establishment, and one result of this work was the recognition that, according to linear theory, the drag rise of such combinations depended only on their distribution of cross-sectional area. The R.A.E. research approach to the area rule has been primarily theoretical, although some completely successful free-flight tests have been performed to confirm the area rule in a special case. Otherwise, experimental confirmation of British theoretical predictions has been obtained from studies of American experimental results. Invaluable methods for estimation of drag rise and optimisation for low drag rise have been developed.

The most significant deduction from the area rule is the intimate inter-dependence of all the parts of an aircraft at transonic speeds. The concept, which has grown up from subsonic experience, of a moderate unfavourable interference drag is completely misleading at such speeds, since the interference drag is often fantastically favourable, and can dominate the drag rise. Attention should therefore be fixed at first on the whole aircraft and not on its component parts. When the overall character of the aircraft is correct, then the design of the components must be considered in detail. A common design problem for a transonic aircraft is: given the wing and its location on the fuselage and given certain specified requirements of the fuselage, the latter should be designed so that the aircraft has the minimum drag rise. This is achieved by making the area distribution of the whole aircraft an optimum area distribution, and then designing local regions with great care. It does not follow that the optimum fuselage must have an exaggerated waist; indeed an exaggerated waist often implies an unwise choice of wing or wing location, or too-stringent restrictions on the fuselage. Thus modifications to the fuselage of an existing aircraft may result in a pronounced waist, but design with full knowledge of the area rule throughout may quite easily produce an unremarkable fuselage shape. In fact, sensational fuselage shapes generally indicate that there was need for great improvement.

Apart from the area rule a completely independent approach by Mr. D. Kuchemann, a German scientist working at R.A.E., had built up a theory of fairing design several years previously which gave much the same clues to desirable aircraft shapes as the area rule. In its present extended form developed in collaboration with Mr. D. E. Hartley, it results in improvements of the transonic and supersonic performance, which are equivalent to those obtained by the area rule.

So far, there are only a few aircraft which show direct application of the area rule. The second method has, however, influenced a number of current aircraft, especially in this country but also in the United States (for example, the Douglas Skyray). In Britain the basic layout of the aircraft often differs from that favoured in the United States. For instance, bomber designs in this country preferred a wing-root installation for the engines to mounting them in pods. This is beneficial in that use can be made of the possibility of suitably designing the wing root rather than modifying the fuselage only. Therefore, such aircraft do not exhibit exaggerated wastlines. Examples are the Handley-Page Victor, the Avro Vulcan and the Vickers Valiant, where an application of the method of Kuchemann has resulted in shapes which are not likely to be further improved by an application of the area rule. The Folland Gnat is a case where the two methods have to a large measure been combined. The English Electric P.1 has been developed in full knowledge of the area rule. Several other aircraft show design trends which have been influenced by the second R.A.E. method. These are mostly alternatives to fuselage waisting. For example, such influences are apparent in the intake design of the Hawker Hunter and Gloster Javelin; in the curved wing tips of the Hunter; and in the fin-tailplane design of the Victor, the Javelin, the Hunter,and the de Havilland 110.

* * *

Letters to the Editor

FREE-PISTON GAS GENERATOR

A Private Patent

SIR, Our attention has been drawn to the details published on page 733 of your issue of November 25, relating to a patent recently taken out in the name of Mr. F. C. Perrott, senior gas-turbine research engineer, W. H. Allen Sons and Company, Limited, for the design of a free-piston gas generator. In view of the fact that inquiries have been received following the publication of details in your columns, we wish to make this company's position clear with regard to the invention.

The inference which has been drawn from the information published is that this company is developing Mr. Perrott's patent. The fact is that the patent is owned privately by Mr. Perrott, who is personally dealing with all developments.

Whilst this company has given encouragement to Mr. Perrott in pursuing the patent, it is already so committed to technical developments in other directions that it is not in a position to take on additional commitments in connection with the invention.

It is hoped that the foregoing explanation will remove any misunderstanding with those of your readers who may be interested in the development of a free-piston gas generator conforming to Mr. Perrott's design.

Yours faithfully,
W. H. ALLEN SONS & CO., LTD.

Queen's Engineering Works,
Bedford.
December 7, 1955.

* * *

SPIRAL-BEVEL GEAR CUTTING MACHINES

British Manufacturer Enters the Field

SIR, We have read with interest Mr. Hugh Clausen's letter in your issue of December 2, in connection with the manufacture of spiral-bevel gear cutting machines in this country, and would advise him that he will see machines of our manufacture on show at the Machine Tool Exhibition at Olympia next June

We would agree with much of what Mr. Clausen says in his letter to you, and it is for this reason that we decided a while ago to develop a range of machines and equipment for cutting spiral-bevel, zerol and hypoid-bevel gears.

Yours faithfully,
DAVID BROWN MACHINE TOOLS, LIMITED,
K. L. OLIVER,
Director.

Britannia Works,
Manchester, 3.
December 7, 1955.

TESTING RELIABILITY OF COMPLICATED MACHINES

Development of Prototypes

Sir, In my paper, "Testing the Reliability of Complicated Machines," previously published in ENGINEERING (November 25, page 723, 1955), it was shown that the rate of breakdown of complicated machines decreased during development trials until it reached a constant value. It was suggested that once this constant value was reached, further prolongation of the trial was uneconomic, so far as reliability was concerned, and that re-design of the machine was indicated.

If this be conceded, it is obviously desirable that the final rate of breakdown should be ascertained at the earliest possible moment in the trial.

It was shown in the previous paper that a model, the reliability of which behaved in all respects the same as that of the actual machine, could be constructed from a few simple families of faults. For all the machines examined to date, two such families suffice—one having n_1 faults of equal probability of occurrence p_1, and the other having n_2 faults, each of an equal probability of occurrence p_2. In general, n_2 is very much larger than n_1, so that the second family of faults is effectively linear to the duration of the trial. Since both these causes of fault exist simultaneously, it should be possible to determine the rate of incidence of the second family, even though the curve showing the total faults against the duration of the trial is still markedly curved.

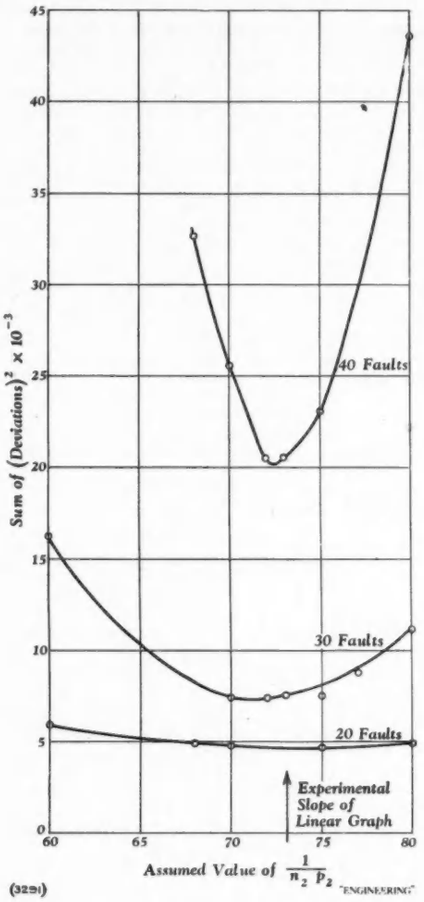
This can be done by the following procedure. Assume a value of $\frac{1}{n_2 p_2}$ and, using this value, calculate the best curve, passing through the experimental points. The traditional measure of excellence of fit is that the sum of the squares of the differences between the experimental points and the calculated values should be a minimum. If, therefore, one plots the sum of the squares of the deviations for the best fit for each assumed value of $\frac{1}{n_2 p_2}$, the points should lie upon a curve which has a minimum value corresponding to a "best fitting" value of $n_2 p_2$.

When this was first tried, the procedure involving $\Sigma \frac{1}{X}$ described in Appendix 2 of the previous paper was used, but it was found that the sum of the squares of the deviations calculated by several workers were not at all consistent. This was traced to the fact that in that procedure the experimental values had to be smoothed graphically, and small differences in the graph drawn by different workers through the same points were sufficient seriously to affect the deviations.

An alternative procedure has been sought, and this is set out in detail in an appendix to this letter. The method leaves no choice to the computer except in the striking out of those values which are to be attributed to the secondary family. Minor mistakes here are found to have but little effect on the final fit. A sample calculation is given in the table below.

The method has been applied to the reliability results for a machine, which were set out in Table I of the previous article, and the sum of the squares of the deviations plotted against assumed values of $\frac{1}{n_2 p_2}$ in the diagram on page 814.

It will be apparent that if only the first 20 faults are used, it is still possible to see that the final rate of breakdown of the machine will be between one failure in 68 and one failure in 80 trials. If the first 30 results are used, then the figure will be between 69 and 74; while if 40 results are used, there is no doubt that the final rate of failure will average one in 72·5 trials,



(3291) "ENGINEERING"

Graph showing $\Sigma\ (T_{obs.} - T_{calc.})^2$ plotted against assumed values of $\frac{1}{n_2 p_2}$ for systems of 20, 30 and 40 faults.

in excellent agreement with the value of one in 73 trials deduced in the previous paper from an analysis of the 42 failures which constitute the linear part of the data. Yet at 40 faults the final reliability has only just been reached, and at least another 500 trials would be needed to find the slope directly.

It may be noted that, using the procedure set out in Appendix 2 of the previous article, the primary faults of the machine were determined as 27, each with a probability of occurrence of 0·0044. Using the new procedure of this paper, n_1 is still 27, but p_1 is 0·00415. From an engineering point of view the difference is negligible, but it may be seen that this change reduces the sum of the squares of the deviations from $3{\cdot}5 \times 10^4$ to $2{\cdot}0 \times 10^4$, a marked improvement of fit.

The calculations set out in the accompanying appendix call neither for special computing skill nor for special equipment. One requires tables of squares and of reciprocals, and Table II of the previous paper is useful. A slide rule is convenient, but not necessary, a desk-type calculating machine may be used for avoiding error during the various summations, but it does not appreciably speed up the calculation. A single point on the graph can be obtained in about 1 to 1½ hours. The cost is therefore trivial compared with that of conducting a prototype trial.

For most engineering purposes it is not necessary to determine the final rate of occurrence of faults to a high degree of precision; what is required is to know whether the final performance is better or worse than some acceptable degree of reliability. For this purpose 20 faults might just have sufficed in the example quoted, while 30 faults would have been ample to determine whether the final reliability was adequate.

Thirty faults had occurred in this experiment after 496 trials, whereas the development trial was continued to 83 faults and 4,021 trials. If the cost per unit period of running the prototype, and an average cost for the modifications which are made to eliminate faults are known, then the saving which might be made by the arithmetical procedure suggested above can be calculated. It will usually be found to represent a marked economy in the cost of development.

TABLE.—Specimen Calculation by the Method of the Appendix (30 faults available; assume $\frac{1}{n_2 p_2} = 75$)

F (1)	$T_{obs.}$ (2)	F_1	$n_1 = 24$	$n_1 = 25$	$n_1 = 26$	$\frac{1}{(n-r)\,p_2}$ (3)	Σ_1 (4)	T_1 (5)	$T_{calc.}$ (6)	$T_{obs.}-T_{calc.}$ (7) +	(7) −	Δ (8)
1	8	1	0·00521	0·00500	0·00481	0·12025	8·3	8·3	8	0	0	0
2	12	2	0·00710	0·00681	0·00654	0·11544	8·7	17·0	17		5	25
3	13	3	—	—†	—	0·11063	9·0	26·0	26		13	169
4	30	4	0·00594	0·00569	0·00546	0·10582	9·5	35·5	36		6	36
5	58	5	0·00394	0·00376	0·00361	0·10101	9·9	45·4	45	13		169
6	64	6	—	0·00419	—	0·09620	10·4	55·8	56	8		64
7	95*	—	—	—	—	0·09139	10·9	66·7	67	28		784
8	97	7	—	0·00331	—	0·08658	11·5	78·2	75	22		484
9	100	8	—	0·00376	—	0·08177	12·2	90·4	78	22		484
10	101	9	—	0·00431	—	0·07696	13·0	103·4	90	11		121
11	107	10	—	0·00465	—	0·07215	13·9	117·3	103		4	16
12	110	11	—	0·00513	—	0·06734	14·9	132·2	117		7	49
13	117	12	—	0·00544	—	0·06253	16·0	148·2	132		15	225
14	125	13	—	0·00570	—	0·05772	17·3	165·5	148		23	529
15	144	14	—	0·00553	—	0·05291	18·9	184·4	150		6	36
16	148*	—	—	—	—	0·04810	20·8	205·2	166		18	324
17	213	15	—	0·00416	—	0·04329	23·1	228·3	184	29		841
18	218	16	—	0·00453	—	0·03848	26·0	254·3	205	13		169
19	220*	—	—	—	—	0·03367	29·7	284·0	225		5	25
20	247	17	—	0·00444	—	0·02886	34·6	318·6	228	19		361
21	248	18	—	0·00493	—	0·02405	41·7	360·3	254		6	36
22	271	19	—	0·00504	—	0·01924	52·1	412·4	284		13	169
23	308*	—	—	—	—	0·01443	69	481	300	8		64
24	334	20	—	0·00459	—	0·00962	104	585	319	15		225
25	351	21	0·00553	0·00494	0·00448	0·00481	208	793	360		9	81
26	359*	—	—	—	—	—	—	—	375		16	256
27	441*	—	—	—	—	—	—	—	412	29		841
28	461	22	0·00494	0·00430	0·00384	—	—	—	450	11		121
29	480	23	0·00578	0·00482	0·00421	—	—	—	481	1		1
30	496	24	0·00761	0·00568	0·00475	—	—	—	525		29	841
											$\Sigma\,\Delta^2$ =	7,546
Mean 1st 4 faults			0·00555	0·00532	0·00510	—	—	—	—			
Mean 2nd 4 faults			0·00596	0·00494	0·00432	—	—	—	—			
Ratio			1·074	0·929	0·847	—	—	—	—			

$n_1 = 25$, $\mathbf{p}_1 = 0{\cdot}00481$, $n_1\,\mathbf{p}_1 = 0{\cdot}12025$

* Assumed to belong to secondary faults.
† Omitted, since T is obviously subject to wide error.

$\frac{S}{n_2 p_2} = 75, 150, 225, 300, 375, 450, 525.$

APPENDIX

A Systematic Procedure to Estimate $\frac{1}{n_2 p_2}$

(1) List in a vertical column the number of faults observed (F). (2) Against this write down the experimentally observed number of trials, hours run, etc., at which these faults have occurred ($T_{obs.}$). (3) Assume a value of $\frac{1}{n_2 p_2}$ and elsewhere list the first few multiples of this number. Note (i) below shows how an intelligent first guess can be made. (4) Strike out of column 2 (see item 2) the numbers which most nearly approximate to these multiples. Regard the remaining values as constituting a single family of faults, and re-number them in sequence (F_1). (5) Assume a value of n_1, which must exceed the total in the F_1 column, and calculate the p_1 value appropriate to each remaining value in column 2. This is done by entering Table II of the previous article at the point corresponding to the assumed value of n_1, and at $(n_1 - F_1)$. Divide the difference between these two entries by $T_{obs.}$ (see Note ii). Select that value of n_1 for which the average for the first four values is as nearly as possible equal to the average for the last four values. Work out the remaining values of p_1 and take the mean, $\mathbf{p}_1$ (see Note iii below). (6) Calculate $n_1\,\mathbf{p}_1$. Write it at the head of column 3 in the position corresponding to the first fault, and successively subtract $\mathbf{p}_1$ from it until the column is exhausted. This tabulates $(n_1 - r)\,\mathbf{p}_1$. This column is self-checking. In column 4 list the reciprocals of the numbers in column 3; only one decimal place is needed. Make a running total of column 4, entering the values in column 5. (7) In column 6 write down the values of column 5 (dropping the decimal points) with the multiples of $\frac{1}{n_2 p_2}$ inserted in the right numerical order of T. Tabulate the difference between column 6 and column 2; examine the results and see if the quantities change sign with reasonable regularity; and also that its algebraic sum is near zero. (8) Square the values of column 7, and sum. (9) Plot the sum of step 8 against the assumed value of $\frac{1}{n_2 p_2}$ and estimate for what value of $\frac{1}{n_2 p_2}$ the graph passes through a minimum.

Notes. (i) A rough value of the final slope can be ascertained by inspection of the data, since the occurrence of a fault from the secondary family in the experimental results in the early stages of the trial causes a discontinuity in the first differences of the tabulated T values. For the data in Table I in the original paper, such discontinuities are found at 64, 110, 148, 220, 248, 359 and 761 trials, showing a periodicity between 62 and 76 units, and a mean value of 70 units. This may be used to guide the assumption of $\frac{1}{n_2 p_2}$.

(ii) If many calculations have to be made it will be found convenient to calculate $\sum_{F=0}^{F=n} \frac{1}{n - F}$ for each value of a range of values of n. This is faster than using the procedure of step 5.

(iii) It is sometimes difficult to judge which of two neighbouring values of n_1 to adopt. The most satisfactory way to decide is to work both to $\Sigma\,\Delta^2$, and to adopt that value giving the smaller final sum.

(iv) The value of $\mathbf{p}_1$ is, of course, affected by the scatter of the experimental data. If inspection of column 7 indicates that a small adjustment of $\mathbf{p}_1$ would improve the fit, such a change is permissible.

(v) Since slide-rule accuracy suffices for this part of the calculation, $\mathbf{T}_1$ (column 5) can be found from $\mathbf{T}_1 = T_{obs.} \frac{p_1}{\mathbf{p}_1}$, at the expense of some loss of self-checking in the calculation.

Yours faithfully,

G. Morris.

Research Dept.,
I.C.I. Nobel Division,
Stevenston,
Ayrshire.
December 8, 1955.

PERSONAL

MR. J. D. PEATTIE, B.Sc., F.C.G.I., M.I.E.E., deputy chief engineer (generation) of the Central Electricity Authority, has been appointed acting chief engineer of the Authority. He takes over the duties of MR. V. A. PASK, C.B.E., M.I.E.E., M.I.Mech.E., who as stated on page 446 of our issue of September 30, retires at the end of the present year.

MR. P. J. C. BOVILL, J.P., assistant managing director of Newton, Chambers & Co. Ltd., Sheffield, has accepted an invitation to join the board of the Wellman Smith Owen Engineering Corporation Ltd., Parnell House, Wilton-road, London, S.W.1. For a number of years there has been a close association between the two companies and Mr. P. G. Roberts, M.P., is chairman of both.

MR. A. HESSELL TILTMAN, B.Sc., F.R.Ae.S., has relinquished his position as chairman and resigned from the board of Tiltman Langley Ltd. His place as chairman has been taken by Mr. W. R. TOMKINSON, T.D., F.C.A., who has been on the board for a number of years.

MR. L. SMITH, formerly works manager of the Daimler Co. Ltd., Coventry, has now been appointed industrial relations officer.

MR. J. C. Y. BAKER, A.R.Ae.S., has been elected chairman of the Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. MR. J. E. GRAY and MR. R. WHITEHEAD have been elected vice-chairman, MR. S. H. HOLE, M.I.Mech.E., honorary treasurer, MR. J. FOSTER PETREE, M.I.Mech.E., M.Inst.N.A., honorary editor, and MR. J. A. ROBERTS honorary librarian.

DR. R. S. MILLARD, B.Sc., A.M.I.C.E., has been appointed head of the newly-formed Colonial Section of the Road Research Laboratory, Harmondsworth, with the rank of deputy chief scientific officer. The formation of a committee of the Colonial Research Council to advise on the work was announced in May. The chairman of the committee is DR. W. H. GLANVILLE, C.B., C.B.E., the director of Road Research.

MR. R. WILLIAMS, assistant to the general manager, No. 1 Area of the Durham Division of the National Coal Board, has been installed President of the North of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle-upon-Tyne, 1.

MR. C. H. BRADBURY, M.I.C.E., M.I.Mech.E., M.I.Mar.E., at present technical director of Petters Ltd., is to join the Simms Group of Companies as chief technical executive officer on January 1, 1956.

MR. D. A. LAW, chief designer, Petters Ltd., Staines, has been appointed chief engineer, as from January 1, 1956, in succession to MR. C. H. BRADBURY.

MR. G. W. ALEXANDER, MR. W. MESSER, and MR. G. W. DAVIDSON, have been appointed directors of the Rhymney Engineering Co., Ltd., which is owned jointly by Powell Duffryn Ltd., and International Combustion (Holdings) Ltd.

MR. M. J. VEREY, T.D., has been elected a director of Dewrance & Co. Ltd., Great Dover-street, London, S.E.1.

MR. J. ALLAN has been made London area sales manager, and MR. D. HUGHES, North-Eastern area sales engineer to J. and H. McLaren Ltd., Leeds.

MR. A. G. DENNIS, LL.M., has joined the board of Camp Bird Ltd., 49, Upper Brook-street, London, W.1, and has been appointed vice-chairman and joint managing director. Mr. Dennis is chairman of the Windsor Group of companies and a director of B.E.T. Omnibus Services Ltd.

The Council of the Institution of Naval Architects have awarded two Denny Scholarships in Naval Architecture, one to MR. I. L. BUXTON of London, S.W.5, and one to MR. A. D. J. MACGREGOR, of Burnley Lancashire. The Aluminium Development Association Post-Graduate Research Scholarship has been awarded to MR. G. WARD, B.Sc., but, as he has now been called for National Service, an interim award has been made to MR. J. D. W. GREEN, B.Sc., of the University of Birmingham. Duke of Northumberland Prizes for 1955 have been awarded to MR. J. G. BELL of the Royal Technical College, Glasgow, and to MR. R. C. CAWS and MR. M. J. RUSHTON of the Southampton Technical College.

British Insulated Callender's Cables Ltd., announce the appointment of MR. G. W. WHEATON, B.Sc., as branch manager in Middlesbrough, in succession to MR. R. N. CRAWFORD who is retiring. The appointment takes effect on January 1, 1956.

MR. R. H. WEST, formerly with Vokes Ltd., Guildford, has joined Creators Ltd., plastics designers and manufacturers, Plansel Works, Sheerwater, Woking, Surrey, as chief buyer.

MR. P. B. LAMING has been appointed manager of development to the Saunders Valve Co. Ltd., Cwmbran, Newport, Monmouthshire.

MR. A. RAYMOND KEY has been appointed vice-president of Johnson, Matthey & Co., Inc., the American associate company of Johnson, Matthey & Co., Ltd.

MR. H. DALE LANGLEY, B.Sc., has been appointed technical manager of Square D Ltd., 100 Aldersgate-street, London, E.C.1.

The names of five members of the new NATIONAL COUNCIL FOR AWARDS IN TECHNOLOGY, particulars of which were given on page 97 of our issue of July 22, when it was announced that LORD HIVES is to be chairman, are: SIR HAROLD ROXBEE COX, Brush Group; SIR ARNOLD HALL, Hawker Siddeley Group; DR. WILLIS JACKSON, Metropolitan-Vickers Electrical Co. Ltd.; DR. IDRIS JONES, National Coal Board; and MR. E. L. RUSSELL, chief education officer, Birmingham.

The members of the BOARD OF STUDIES IN ENGINEERING nominated by: *The Assoc. of Principals of Tech. Inst. and the Assoc. of Teachers in Tech. Inst.* are MR. H. S. BARLOW, S.E. Essex Tech. Coll., Dagenham; DR. F. BRIERS, Norwich City Coll. and Art School; DR. W. A. J. CHAPMAN, Hatfield Tech. Coll.; MR. H. W. FRANKLIN, Northampton Polytechnic, London, DR. G. LAWTON, Sheffield Coll. of Commerce and Tech.; MR. D. A. G. REID, Brixton School of Building; DR. A. J. RICHMOND, Cardiff Coll. of Tech. and Commerce; DR. E. C. SMITH, Wigan and Dist. Min. and Tech. Coll.; DR. J. S. TAIT, Woolwich Polytechnic; and MR. C. J. TIRRELL, Crewe Tech. Coll. *I.ChemE.:* MR. J. A. ORIEL. *Inst.C.E.:* PROFESSOR A. J. S. PIPPARD, City and Guilds Coll., and MR. P. E. SLEIGHT, Brighton Tech. Coll. *I.E.E.:* MR. S. E. GOODALL, W. T. Henley's Telegraph Works Co., Ltd., and MR. G. S. C. LUCAS, British Thomson-Houston Co., Ltd. *I.Gas.E.:* MR. J. H. DYDE, Eastern Gas Board. *I.Mech.E.:* Mr. T. A. CROWE, North British Locomotive Co. Ltd., and PROFESSOR E. GIFFEN, Queen Mary Coll., London. *Inst.Min.E.:* PROFESSOR J. A. S. RITSON. *I.Prod.E.:* SIR WALTER PUCKEY. *I.Struct.E.:* DR. S. B. HAMILTON. *R.Ae.S.:* PROFESSOR A. R. COLLAR, Bristol Univ. *Minister of Education:* MR. T. E. GOLDUP, Mullard Ltd.; MR. H. W. CREMER, MR. J. J. GRACIE, General Electric Co. Ltd.; DR. T. E. ALLIBONE, and PROFESSOR D. G. CHRISTOPHERSON, City and Guilds Coll.

The members of BOARD OF STUDIES IN TECHNOLOGIES OTHER THAN ENGINEERING include: DR. F. H. COTTON, Northern Polytechnic; MR. H. W. DERRY, Battersea Polytechnic; MR. N. M. H. LIGHTFOOT, Chelsea Polytechnic; DR. J. TOPPING, Acton Tech. Coll.; DR. A. M. WARD, Sir John Cass Coll.; DR. G. E. WATTS, Brighton Tech. Coll.; MR. W. W. WILKINSON, Coventry Tech. Coll.; PROFESSOR F. A. VICK Univ. Coll. of N. Staffs.; MR. G. A. WHIPPLE, Hilger & Watts Ltd., and DR. F. KIDD, D.S.I.R., and DR. A. D. MERRIMAN, MR. G. E. HOLMES-SIEDLE, MR. W. A. COOK, DR. V. E. YARSLEY and DR. C. WHITWORTH.

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COMMERCIAL

An agreement has been signed between the BRISTOL AEROPLANE CO. LTD., and the FIAT CO., in Turin, Italy, regarding the installation of the Bristol Orpheus turbo-jet engine in the Fiat G-91 light fighter, ordered for N.A.T.O. The agreement aims at carrying out the joint project in the most effective manner and gives Fiat the option to manufacture, under licence in Italy, the Orpheus and engines developed from it.

BROOK MOTORS LTD., Empress Works, Huddersfield, have purchased a 28 acre site at Hope Bank, Honley, some 4 miles from their present works, for new factory development.

DOULTON & CO. LTD., Doulton House, Albert-embankment, London, S.E.1, announce that while the overall control of their business will continue to be exercised from the head office at Doulton House, London, four main production branches will be given separate entities and operate as wholly-owned subsidiary companies, as from January 1, 1956. An existing subsidiary company, WHIELDON SANITARY POTTERIES LTD., Stoke, will be renamed DOULTON SANITARY POTTERIES LTD., and three new subsidiary companies will be created, namely, DOULTON FINE CHINA LTD., Burslem, DOULTON INDUSTRIAL PORCELAINS LTD., Tamworth, and DOULTON VITRIFIED PIPES LTD., Erith.

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have opened a new depot at Magnet House, Derby-street, Preston, under the management of MR. R. G. GALLOWAY. (Telephone: Preston 57871/2.)

THE COMPOFLEX CO. LTD., 26 Grosvenor-gardens, London, S.W.1, have appointed NEW DUCTS, 67A Downs Park-road, London, E.8, to be stockists for WYREM dust-extraction and ventilation hose.

THE BELARK TOOL AND STAMPING CO. LTD. have moved to 9 Carnaby-street, London, W.1. (Telephone: GERrard 2178.)

Plans are now complete for extensions to the King's Norton, Birmingham, factory of the TRIPLEX SAFETY GLASS CO. LTD. Work has already started on the new extensions which will have an area of approximately 46,000 sq. ft., and will cost about £250,000.

DOWDING AND MILLS LTD., industrial electrical repair specialists, of Birmingham and London, have now started their own electrical contracting organisation in Birmingham, and have appointed MR. J. ROBINSON manager of this department.

THE ROCKWELL MACHINE TOOL CO. LTD., Welsh Harp, Edgware-road, London, N.W.2, have been appointed sole agents for the ELERODA D.1 spark erosion machine manufactured by ATELIERS DES CHARMILLES S.A., Geneva, Switzerland.

A reorganisation of SOCONY MOBIL OIL CO. INC., will take effect on January 1, 1956, with the establishment of a wholly-owned affiliated company, MOBIL OVERSEAS OIL CO. INC. This will integrate, and be responsible for, all activities of the Socony Mobil Co. and its affiliate companies in the Eastern Hemisphere and Latin America, except for its interest in STANDARD VACUUM, interests within Middle East concessionary areas, and producing operations in Venezuela, Colombia and Peru. The headquarters of the new company will be at 26 Broadway, New York, until next summer, when they will be moved to the new Socony Mobil building at Lexington-avenue and 42nd-street, New York.

ELECTRICAL ENGINEERS (ASEE) EXHIBITION LTD., have moved to larger premises at 6 Museum House, 25 Museum-street, London, W.C.1, where all correspondence should be addressed. The registered office remains at 23 Bloomsbury-square, London, W.C.1. The telephone, MUSeum 3450, remains unchanged.

ELECTRO METHODS LTD., Caxton-way, Stevenage, Hertfordshire, have completed a licensing arrangement with WINCHESTER ELECTRONICS INC., U.S.A., to manufacture miniature, sub-miniature, self-separating, hermetically-sealed and printed-circuit connectors, stand-off terminal insulators and other electrical components.

THE ELECTRIC AND MUSICAL INDUSTRIES GROUP, Hayes, Middlesex, and the CINCINNATI MILLING MACHINE CO., U.S.A., have concluded an agreement providing for the integration of the study and development of electronic machine-tool control equipment.

THE PLESSEY CO., LTD., Ilford, Essex, announce the formation of PLESSEY RESEARCH LTD. The chairman and managing director will be MR. A. G. CLARK, and the other directors include MR. B. G. W. ATTWOOD, MR. E. J. EARNSHAW, MR. MICHAEL CLARK and MR. G. C. GAUT.

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CONTRACTS

Ammonia Production Plant. In connection with a new project by Imperial Chemical Industries Ltd., at Billingham, for producing ammonia from synthesis gas made by pressure gasification of oil with oxygen, an order has been placed with ROBERT DEMPSTER & SONS LTD., Rose Mount Iron Works, Elland, Yorkshire, for GASTECHNIK purifiers using pelleted oxide of iron. A pressure section will remove the hydrogen sulphide remaining after a pressure washing process and a low-pressure section will remove the hydrogen sulphide from the carbon dioxide liberated from the washing process. As an essential to the process, the plant will include solvent extraction equipment for recovering sulphur from the spent iron-oxide pellets, which will then be re-used.

Diesel Engines for Tractors. An order totalling more than 1 million dols. has been placed by Cockshutt Farm Equipment Ltd., Brantford, Ontario, Canada, with F. PERKINS LTD., Peterborough. It is for Perkins L4 Diesel engines for installation in the Cockshutt "40PD" 3-4 plough, four-wheel tractor designed for the Canadian home and export market. Deliveries have already commenced and will be completed before next summer.

Cranes. Two contracts for mobile cranes, the value of which exceeds £120,000, have been secured by R. H. NEAL & CO. LTD., Plant House, Ealing, London, W.5. The cranes have been ordered by the Egyptian Republic Railways and the Persian Customs Department.

Electrical Transformers. The Tennessee Valley Authority, Chattanooga, U.S.A., have placed a contract for the manufacture and delivery of four transformers with the ENGLISH ELECTRIC EXPORT AND TRADING CO. LTD. This, we are informed, is the first occasion on which this Authority has accepted an English Electric Co.'s tender. The transformers are single-phase with three windings for 154/69/13·8 kV. They are of the outdoor self-cooled type and are rated at 40,000 kVA, 60 cycles. Other transformer orders received by the firm from the United States include those for the St. Lawrence power project (120 MVA, 230 kV); the City of Seattle (125 MVA, 230 kV); the Chief Joseph dam (310 MVA, 220 kV); the Bonneville Power Administration (250 MVA, 254 kV); the Folsom dam, California (80 MVA, 230 kV), and the Table Rock dam (121 MVA, 161 kV).

RESEARCH ON RELATION BETWEEN SOUND AND HEARING

COMPLETION OF FOUR YEARS WORK AT THE N.P.L.

It has been announced recently by the Department of Scientific and Industrial Research that an extensive research, which has occupied about four years, for the purpose of determining the relationship between the intensity and the loudness of pure tones, has been completed at the National Physical Laboratory, Teddington, and the results are to be published in the near future.

The object of the research is to relate the intensity of a sound to its loudness, the former being a physical property which can be measured directly and the latter being a subjective characteristic dependent upon the behaviour of the normal human ear. To persons with normal aural acuity high-frequency sounds are much louder than low-frequency sounds of the same intensity, though to elderly persons pure tones at very high frequencies are generally quite inaudible.

Some experimental work on equal-loudness relations was carried out by Fletcher and Munson, of the Bell Laboratories, in 1933 and by Churcher and King of the Metropolitan-Vickers Electrical Company, in 1937. As the former were required for use in telephone transmission problems and the latter for studying the noises of electrical machinery, the experimental methods were different and the results more or less discordant. When, therefore, the British Standards Institution, just before the second World War, were endeavouring to establish standards for noise measurement, it was thought necessary for a new series of experiments to be carried out under carefully controlled conditions.

The National Physical Laboratory was invited to undertake the work and agreed to do so, using the facilities available in the Acoustics Laboratory. The work was deferred owing to the outbreak of the war and was not commenced until 1951. It has recently been completed, as mentioned previously, Mr. D. W. Robinson having been in charge throughout.

The measurements were made in one of the "quiet" rooms of the Acoustics Laboratory, this room being completely insulated from all extraneous sounds and vibrations and also being quite free from echo. High-frequency pure tones were produced by a group of comparatively small loudspeakers arranged in a plane in order to give a reasonably plane wavefront. The very low frequency tones were produced by an acoustic duct. Individual tests were made with 130 living subjects of both sexes and of ages ranging from 16 to 63 years. All were members of the Laboratory staff and all had normal hearing, so that the results may be regarded as truly representative. It is considered therefore that the data obtained will serve as a reliable guide in the study of problems in noise abatement by indicating which and to what extent the various components should be suppressed in order to reduce the noise to a tolerable level.

HOW ELECTRICITY ASSISTS THE COAL MINER

The Faraday Lecture

The 1955–56 Faraday Lecture of the Institution of Electrical Engineers was delivered at Cardiff on Thursday, December 1, by Mr. B. L. Metcalf, chief engineer of the National Coal Board. The lecture, which is of a popular character, was also given at Stoke-on-Trent on Wednesday, December 7, and will subsequently be repeated in London on Wednesday, February 15, 1956, and in other provincial centres during the New Year. It was intended to show how electrical energy was being used to help the miner by giving him more power and by improving his working conditions. Electricity for lighting; ventilation; pumping; hauling, winding, conveying and preparing coal; transporting men and material; communication; and electro-medical services received special mention.

There were close links, said the lecturer, between Faraday and coal mining. He worked with Sir Humphrey Davy on the famous safety lamp and investigated a colliery accident at Haswell, near Durham, in 1844. In his report he suggested a method of draining methane from colliery workings, which was very similar to that now being employed.

The first recorded use of electricity in a coal mine was in a Scottish colliery in 1881; and the industry now consumed 4,000 million kWh annually. It was soon recognised that there were dangers in employing this form of power, although until 1911 it was generally supposed that the immersion of the contacts in oil rendered a switch flame-proof. After several explosions, however, a more definite enclosure was sought and a complete range of certified and intrinsically safe equipment was now available for use underground.

At first it was also thought that open sparking from power circuits was the only source of danger. A serious explosion at a South Wales Colliery in 1913, which resulted in the loss of 439 lives, led, however, to signalling apparatus becoming suspect, and it was later proved that inductive sparks from such circuits could readily ignite firedamp.

More ingenuity had been shown by the electrical engineer in the field of winding men, minerals and materials up and down the mine shafts than in any other. In support of this statement the lecturer gave a demonstration of a tower-mounted cage winder, which was operated from a control desk with appropriate signals and a tape-type signal recorder. The way in which photo-electric cells could be used to prevent a winder from operating if anything was projecting from the cage was also shown, while a film sequence illustrated how the winding cycle could be monitored under all conditions of load.

Two major technical advances had led to greatly improved lighting in mines—the development of higher voltages and more efficient batteries and the substitution of argon-filled by krypton-filled bulbs. Krypton gas allowed the filaments to be operated at a higher temperature, thus giving 40 to 50 lumens from a miner's lamp with a bulb little larger than that of a motor-car side light.

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BOLD "A" POWER STATION

We regret that in the description of the 120 MW Bold "A" power station, which appeared on page 514 of our issue of October 7, it was stated that the 36 MVA 11·8/35·4 kV generator transformers were manufactured by Brush Electrical Engineering Company, Limited, instead of by Metropolitan-Vickers Electrical Company, Limited.

We are also asked to state that 36 motors with outputs of from ½ to 240 h.p., and including those driving the pulveriser mills, exhausters, induced draught and forced draught fans and separators, were also supplied by Metropolitan-Vickers Electrical Company, Limited.

Obituary

MR. F. W. PURSE

A Versatile Electrical Engineer

We regret to record the death of Mr. F. W. Purse, which occurred on Thursday, November 24, at the age of 76. He was for many years connected with the electrical power industry and was well known as an energetic propagandist for greater electricity consumption and a dogmatic critic of certain aspects of the hieratical policy.

Frederick Walter Purse was born on February 2, 1879, and was educated at Merchant Venturers School and Technical College, which now forms part of the University of Bristol. In 1897 he became a pupil of Mr. H. Faraday Procter, who was then chief of the Corporation Electricity Department in that city, and two years later was appointed engineer-in-charge in the Bath Electricity Department. From 1901 to 1908 he was chief assistant electrical and tramways engineer at Warrington, and became chief electrical engineer of the Watford Electricity Department in the latter year.

He subsequently served in similar capacities at Carlisle and West Ham where he played a leading part in stimulating the domestic load. In 1929 he became chief engineer of the London and Home Counties Joint Electricity Authority, a post he held until his retirement in 1946 and in which under somewhat difficult circumstances he displayed the same qualities as in his earlier municipal appointments. Thereafter he acted first as director and then as honorary director of the National Register of Electrical Installation Contractors.

Mr. Purse was elected an Associate Member of the Institution of Mechanical Engineers in 1904 and was transferred to the class of Member in 1913. He also became an Associate Member of the Institution of Electrical Engineers in 1904 and a Member in 1912. He had served on the council of the latter body, as vice-president from 1931–1934 and as chairman of the Transmission Section in 1939–40. He was president of the Incorporated Municipal Electrical Association in 1927–28, president of the Building Industries National Council from 1946 to 1948, as well as being chairman of the Electrical Development Association in 1940–41 and of the Institution of Electrical Engineers Wiring Rules Committee from 1928 to 1934.

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We also regret to record the deaths of:

MR. FREDERIC COLIN BURSTALL, on December 7, at the age of 66. After being educated at Magdalen College School, Oxford, he joined the National Telephone Company in 1904. Subsequently he served in the traffic branch of the Post Office and as Deputy Director-General of Posts and Telegraphs of the Egyptian State Railways. He became a member of the staff of the Automatic Telephone and Electric Company in 1931, and at the time of his death was managing director.

MR. A. A. KIFT on December 4 at the age of 75. He was trained at Finsbury Technical College and joined the engineering staff of Marconi's Wireless Telegraph Co. Ltd., in 1902. He was at first engaged in the installation of wireless equipment on the vessels of the White Star fleet and other ships, as well as in shore stations. He subsequently dealt with administrative matters, becoming successively sales manager, assistant engineer-in-chief and contracts manager. He retired in 1945.

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ATOM EXHIBITION: 1957

The first international "Atoms for Peace" exhibition, held in Geneva from August 8 to August 20, 1955, has proved so successful that in response to general demand the organising committee has decided to hold a similar exhibition at Geneva in August, 1957. With regard to the first exhibition, the excess of receipts over costs has been such as to permit a refund to the exhibitors of 32 per cent. of the renting price for stands. Communications should be sent to 1 Place du Lac, Geneva.

Book Reviews

THE GERMANS DO IT AGAIN

A Brief Review of Science and Technology in Western Germany. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s*.)

To review a review is asking for trouble, particularly when, as in the present case the original is packed so full of information; the only excuse may be, indeed, that the present document is so tightly packed that the reader who is not well acquainted with Germany might be left unable to see the wood for the trees. He might also be deterred from reading it as thoroughly as it deserves to be read by wondering at times whether he was reading a critical assessment, such as might be expected in a document sponsored by the British Department of Scientific and Industrial Research, or a high-pressure sales boost put out on behalf of West German industry.

Anyone who feels inclined to doubt the importance of the topics dealt with in this document should pause to consider the phenomenal recovery of West German industry from early in 1947, when realisation dawned that the Morgenthau conception of a pastoral Germany was nonsense, to the present day when German industrial competition is proving a serious worry to whole industries. Admittedly American capital primed the pump, but no amount of priming will enable a pump to run which is neither soundly constructed nor supplied with adequate power. The phenomenal growth of German industry during the past eight years has been due in large measure to a number of interlocking factors, all of the greatest significance, yet seldom all listed together due to the regrettable tendency to view problems through the eyes of the specialist rather than through those of the general practitioner. The order of importance is impossible to define, and what follows is not intended to suggest that one point is more important than another.

The effect of Allied bombing and post-war policy was to put out of business a very large number of inefficient firms, and to present to many of those with the will and the ability to survive the advantages of an erased factory and two years of enforced idleness in which to consider the fundamentals of their businesses and to plan for the day when a new start would be possible. In addition, the many Allied investigating teams presented them indirectly, via the questions asked, with the fullest possible survey of the problems facing their competitors. Visitors to German firms to-day are often shown shops left standing from before the war with the comment that the firm was once glad enough to have anywhere to restart work, but could wish now that erasure had been complete.

Financial policy in Western Germany has been directed at encouraging high earnings by low direct taxation and high indirect taxation (anathema to the classical political economist), while direct incentive to earn high wages has lain in the widespread loss of personal goods, and the fact that most people lacked even the essentials of elementary civilised comfort. That Germany is now running into difficulties similar to our own may be ascribed to the same lack of willingness to save, due in their case to two currency reforms in 25 years, in ours to the means test. The small man in the United States, having known neither, is more thrifty. Incentives, however, are only one aspect of the industriousness of those engaged on manual labour; tradition is of far greater importance. Germany is still to a far greater extent than England a rural country, and anyone who has worked in both small and large towns will know what this implies. Even more important, however, is the tendency to imitate those for whom they work. In England, the typical reaction to earning more money is to work shorter hours and to take longer holidays; in Germany, 8 a.m. is as good a time to catch a director at his desk as any other. This is not necessarily admirable; it is just a fact. Another aspect of the same matter is to be found most forcibly expressed in the B.I.O.S. investigation report on the firm of Leitz (makers of the Leica), where comment is made on the modest style of life of the owners of the firm, and the size of the sums ploughed back into development.

None of these things would have helped German industry, faced with a loss of manpower such as we can scarcely visualise, had it not long since decided that technical education at every level was of prime importance. Even the smallest firm runs proper apprentice training schemes leading to the journeyman's examination at 18 and the master's examination at 21. The reserve of craftsmen which this implies was one of the major factors in the technical side of the last war, and has made possible much of the rapid reconstruction since. Possibly of even greater importance is the weight laid on proper academic training, and the significance of the fact that with populations of roughly equal size, Germany is at present training three times as many men each year to Higher National Certificate level needs no comment. Equally significant, however, is the fact that from the beginning of the century until 1939, Germany has produced about three times as many engineering graduates as Great Britain, although to-day we are producing approximately equal numbers. As a result, much sound analytical work has been done in Germany in fields which have scarcely attracted the attention of professional engineers in this country, and firms are far more ready to make use of the work done in the technical universities than is the case here, where the gap between what is known by the average professor and what is applied by the average firm is enormously greater than is the case in Germany. This is not to suggest that they do not have their troubles; articles in the German technical Press have recently been attacking their methods of technical education just as heartily as ones here have attacked ours!

So much for a general framework; many readers may think that the most valuable chapters in this book are the first and the last—the first because it surveys general trends, organisation and finance; the last because it looks, however superficially, at productivity in industry. Those in between are a hotch-potch of detailed and general information, with little to indicate what of it is original and what propaganda. Significantly, perhaps, no mention is made of the admirable research work being carried out at Darmstadt for the paper industry—but then its director is a modest man. This and other omissions, which anyone knowing German industry well will note, serve to underline the need for a companion volume to put what is reported in proper perspective relative to our own performance.

Power Plant Management. By ROBERT HENDERSON EMERICK. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6.50 dols); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (49*s*.)

The title of this book would appear to indicate that it is concerned with the operation of power plants. It is; but it covers much more ground than is comprised under that term. It is stated that power plant management naturally falls into the three categories of design, administration and operation. This does not mean that "top management" concerned with the layout and running of a power plant is required, or is competent, to design the boilers, turbines or other items of which the plant is made up. It does mean that if it is to do its job most effectively it must be able to select the type of plant most suitable for the load to be carried and for such local conditions as the type of fuel most readily available and the nature of the water supply; alternatively, it must be capable of selecting designers or consultants competent to do this.

The book is concerned with the small, or average, works power plant, not with central-station design or operation. Throughout, the word "management" is used to designate those who are ultimately responsible since they appoint staff and control expenditure. Mr. Emerick instances a hospital power plant on which he reported; he found that the entire boiler room was coated with coal dust, with rubbish and rags mouldering in the corners, that the automatic boiler control had been inoperative for two years and that the firemen could neither read nor write. No doubt the firemen were directly responsible for the dirty state of the plant, but the obvious lack of supervision and maintenance was due solely to the irresponsibility of the management.

The subject of the book is treated in three main sections, dealing respectively with design, administration and operation. The management of any industrial establishment requiring the provision of a power supply is faced with the problem of either generating power or purchasing it from a public supply authority. This matter is fully discussed, the advantages and disadvantages of each procedure being presented. In many works, the necessity of providing for process steam will favour the installation of a boiler plant and steam turbines, although if process steam is required only in small quantity it might be provided by waste-heat boilers in conjunction with a Diesel plant. These matters, and the claims of gas turbines, are dealt with in detail, but whatever choice is made two basic decisions can be taken only by management. These are, how much capital may be expended and what provision is to be made for future extensions. It is suggested that the shape of the load curve over at least ten years should be predicted. This will largely be determined by commercial policy which is a matter for management, not for its technical staff.

The section concerned with administration deals with such questions as the losses which may be caused by false economy leading to neglected maintenance and, for instance, inadequate provision against accidents. These may seriously interrupt production and may be expensive. The design and installation of safety appliances are matters for works' superintendents, but permission to pay for them must be given by management. Safety is closely related to provision against fires, which is dealt with in the section on plant operation. Frequently, protective arrangements have been found defective, owing to inadequate maintenance, just when they were required. A serious fire, apart from direct loss, may result in the severing of connections with regular customers. This is very much a matter of interest to management.

This book clearly embodies the results of wide experience and contains a remarkable amount of practical advice which should be of value to those directly concerned with the operation of power plants. The information about firing boilers in such a way as to avoid the production of smoke is an example, but even here the responsibility of management is involved in the provision of suitable plant. In a sense, the leitmotiv of the book is the relation between capital expenditure and efficient operation. The chapter on the selection of coal, for instance, relates the cost of the cheaper qualities to the capital expenditure necessary to burn them effectively.

Two chapters worthy of particular mention are those dealing with outdoor power plant and the purchase of second-hand machinery. The first describes and illustrates a number of outdoor plants and states that, compared with "the typical temple of power common during the 1920's," the saving in cost might be "breath-taking." About one in five of new public utility plants in the United States are tending towards outdoor design. The chapter dealing with the purchase of used equipment gives in detail the points to which particular attention should be directed and the defects most likely to be found in boilers, turbines, condensers and the other classes of plant.

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Flat-Bottom Railway Rails. (4*s.*, post free.)

A fifth revision of B.S.11, covering flat-bottom railway rails has been in hand for some time. Further investigations are being made into proposed new rail sections, but work on the remainder of the specification having been completed, it has been decided to issue this separately as Part 1. The present British Standard rail sections will be retained for the time being and, on the issue of Amendment No. 4 to B.S.11:1936 will now be known as B.S.11:Part 2. A new edition of Part 2 will be issued as soon as work on the revision of the sections is completed.

The new publication (B.S.11, Part 1:1955) specifies the quality of the material, its chemical composition and mechanical properties and includes requirements for lengths and for the condition of the finished rails and other matters. It differs from the previous (1936) edition in a number of respects, the main changes being the deletion of grades other than the so-called "medium-manganese" grade and the inclusion of dimensional tolerances.

Helical and Volute Springs for Railway Rolling Stock. (4*s.*, post free.)

Another revision which also relates to railway material, B.S.24: Part 3B: 1955, has now been issued. It deals with helical and volute springs and spring steels for railway rolling-stock material. This, the sixth revision of Part 3 of the specification, covering springs and spring steel, has been in hand for some time. That portion concerned with laminated springs and the flat bars from which they are manufactured is still under consideration. Since, however, agreement has been reached on the requirements for helical and volute springs and for the bars for their manufacture, it has been decided to issue this Part (the present Part 3B) separately. This specifies the following requirements: hot-rolled spring-steel bars for helical and volute springs and the springs made from this material; steel helical springs cold coiled from a drawn material; ground spring-steel bars for helical springs, and helical springs made from round-section ground steel bars.

Also covered are the chemical compositions of the steels, the quality of the material, and the tolerances to which these springs are to be made. An appendix contains the recommended method for calculating the total number of coils for helical compression springs.

Oxy-Acetylene Welding of Steel Pipelines and Pipe Assemblies. (7*s.* 6*d.*, post free.)

A new specification, B.S.2640, relating to Class II oxy-acetylene welding of steel pipelines and pipe assemblies for carrying fluids, has now been issued.

Lack of uniformity in welds employed for the joints in pipe and pipe assemblies carrying fluids and for securing flanges and attachments, such as anchor plates, to pipes and tubes, can result from variations in practice as regards weld preparation, welding and heat-treatment procedures, the training and testing of welders, and the inspection and testing of production welds. Good practice in all these respects having now been established, a series of process standards is being issued to cover the production of welds in pipe assemblies of any material used sufficiently widely to warrant its inclusion.

The new specification covers the shop and site oxy-acetylene welding of steel-pipe and tube assemblies in sizes up to 20 in. diameter and of a thickness not exceeding $\frac{1}{4}$ in. It covers all types of butt joints, branches and sleeve welds and contains also qualifying tests for welders. Recommendations for welding techniques and the method of preparation for macro-etching are set out in appendices.

Drafting Specifications Based on Limiting the Number of Defectives in Small Samples. (2*s.* 6*d.*, post free.)

A publication entitled "Drafting Specifications Based on Limiting the Number of Defectives Permitted in Small Samples" and designated B.S.2635, has been issued. It is by Dr. B. P. Dudding, M.B.E., vice-chairman, Advisory Scientific Panel, G.E.C. Research Laboratories, and is intended chiefly for those concerned in the drafting and use of clauses in British Standard specifications based on a statistical analysis of the results of sampling. The publication deals with the application of theoretical data to guide the drafting of specification clauses designed to determine the acceptance or rejection of consignments of articles or materials by tests made on small samples.

Proposals for the publication of other documents of a similar nature are being considered.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Electric Power Stations. Vol. II. By T. H. CARR. Fourth edition. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (80*s.*)

The fourth edition of this well-known textbook, which first appeared in 1941, deals with condensing and feed water heating and treatment plants; alternators, transformers and reactors; switchgear, cables; lubricating, insulating and fuel oils; station auxiliaries; protective equipment; lighting; commissioning and listing of plant; organisation; and fire fighting and air raid precautions. Although it relates mainly to steam stations there are supplementary chapters on hydro-electric, Diesel, gas-turbine, wind, atomic and other power plants. Since the last edition in 1949 a good deal of new material has been added and the whole has been thoroughly revised.

Report on Natural Gas and Methane. Prepared by the Institution of Gas Engineers, at the request of the Gas Council. *The Gas Council, 1 Grosvenor-place, London, S.W.1.* (1*s.* 6*d.*)

The report covers three aspects of the use of natural gas and methane: distribution of the gases from their point of collection; domestic and industrial applications; and the reforming of the gases.

Peru. Overseas Economic Survey. By J. D. JAMIESON. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s.* 6*d.*)

The survey points out that in Peru there are no exchange controls, and this, together with the virtual absence of restrictions on imports, makes it a very attractive market for the British exporter. Peru imports principally machinery, textiles, chemicals and metal manufactures from the United Kingdom; and textiles, in spite of rising duties, can be expected to hold their own in the better class market in competition with the local product. Full information is given in the survey concerning Peruvian agriculture, mining and industry, together with full details, including tables, of imports and exports.

Surveying Practice and Statutory Plans, Part II. National Coal Board (Production) Codes and Rules. *National Coal Board, Production Department, Hobart House, Grosvenor-place, London, S.W.1.* (15*s.*; 12*s.* 6*d.* to University students.)

The first volume of this publication, which was issued in 1952, was designed to establish within the Board's organisation, standards of practice and accuracy in surveying and in the preparation of certain statutory mine plans. This second volume extends the scope of Part I and sets out the styles which the Board have decided are to be adopted for operational as well as statutory plans.

The Thermal Insulation of Buildings: Design Data and How to Use Them. By G. D. NASH, J. COMRIE and H. F. BROUGHTON. Published for the Department of Scientific and Industrial Research, Building Research Station, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (12*s.* 6*d.*)

This publication, compiled by the Building Research Station, is intended as a manual for the use of building designers, giving in conventional form a guide to the use of heat insulating materials, their performance and their cost. It begins with an outline of the principles of thermal insulation which, while not attempting to deal comprehensively with the theory of the subject, does provide an adequate background to enable the reader to make best use of the data sheets and tables that follow. These deal with the properties of the various insulating materials available, including typical costs of wall and floor construction.

Advanced Mathematics for Engineers. By H. W. REDDICK and F. H. MILLER. Third edition. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (6.50 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (52*s.*)

A firm basis in advanced mathematics is essential for a full understanding of current developments in engineering theory and practice, and the object of this book is to provide that foundation, first by presenting definitions, physical laws, theorems and units as clearly as possible and secondly by showing how they may be used in civil, mechanical, electrical and chemical engineering. Operational calculus, Fourier series, vector analysis, elliptic integrals, gamma and Bessel functions, functions of a complex variable, Legendre's equation, Laplace transformations and the reversion of power series are among the subjects treated; and examples of applications include edge effect in a condenser, flow of heat, electricity and fluids, diffusion problems, capillarity, vibrating strings, electrical networks, eddy currents and structural analysis. The present edition has been prepared by F. H. Miller, Professor and Head of the Department of Mathematics, the Cooper Union School of Engineering, U.S.A., who is one of the authors. The book contains numerous problems, to all of which answers are provided; there is also a comprehensive index.

National Electrical Code Handbook. Based on the 1953 edition of the National Electrical Code. By ARTHUR L. ABBOTT. Eighth edition, revised by CHARLES L. SMITH. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (56*s.* 6*d.*)

The purpose of this Handbook is to provide a guide to the American National Electrical Code. It consists of a reprint of that document, each clause of which is followed by an explanatory note where that is considered necessary. Wiring design and protection, methods and materials, equipment for general and special use and communication systems are all covered.

Repairing Record Changers: A Practical Guide to All Models, including Portable Phonographs, High-Fidelity Units and Magnetic Tape Recorders. By E. EUGENE ECKLUND. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (5.95 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (44*s.* 6*d.*)

A practical guide instructing the reader how to start a record changer repair business either as a full-time business or as an extra-income side line.

Analysis Directory of Canadian Coals, Supplement No. 1—1955. By E. SWARTZMAN and T. E. TIBBETTS. *Department of Mines and Technical Surveys, Mines Branch, Fuels Division, Ottawa, Canada.* (75 cents.)

The present publication is an interim supplement to the *Analysis Directory of Canadian Coal*, dated 1953, and gives data relating to mines where there has been a change in output since the regular edition was published. The arrangement of data is according to province, and within each province by county and field, each mine being listed alphabetically. For each mine, details are given of locality, size and output, and of chemical and physical analyses of the coal which is mined, all the data being arranged in tabular form.

Technologie von Graugusstücken. By RICHARD MEYER. *Wilhelm Knapp Verlag, Halle (Saale), Mühlweg 19.* (14.50 D.M.)

This book on "Technology of Castings" is divided into four main chapters: melting furnaces, specifications of various classes of cast iron and the German Standards relating to it, special quality classes, and examples of time saving methods in moulding. Various melting furnaces are discussed (cupola, electric-arc furnace, low-frequency induction furnace and oil-fired furnace). Examples are given for a great number of special castings, such as heat-resisting castings, moulds for steel castings, retorts for carbon disulphide and other special castings for the chemical industry.

Prüf-, Mess- und Kontroll-Geräte-Lexikon. By HANS HADERT. *Hadert-Lexikon-Verlag, Martin-Luther-Strasse 88, Berlin, W.30.* (38 D.M.)

This book lists in 800 pages German and foreign measuring, testing and controlling instruments. They are divided into 96 groups with many illustrations. It has been compiled by the author in co-operation with the makers of the listed instruments. Explanatory notes are provided which describe the field of application and the basic principles of operation. In order to avoid the potential danger, arising from the co-operation of the makers, of the book becoming something like a collection of excerpts from makers' catalogues, the explanatory notes have not been written by the makers' experts, but by an independent and unbiased writer. Many bibliographical notes make it possible for the interested reader to obtain additional information.

General Mechanical Drawing. By WILLIAM JERVIS. *International Textbook Company, Scranton, Pennsylvania, U.S.A.* (3.20 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (21*s.*) (Reviewed on page 785, in the issue of December 9.)

An Illustrated History of Science. By F. SHERWOOD TAYLOR. *William Heinemann, 99 Great Russell-street, London, W.C.1.* (25*s.*) (Reviewed on page 785, in the issue of December 9.)

Fig. 1 Interior view of Boeing flight test hangar, 785 ft. long, 200 ft. wide and 90 ft. high. The doors, closed in this illustration, slide vertically to give a clear opening, unobstructed by pillars, 780 ft. long.

SOME ASPECTS OF THE AMERICAN AIRCRAFT INDUSTRY

(2) DEVELOPMENT AND RESEARCH TRENDS

Last week we described some of the varied activities of the aircraft, engine and component firms that we visited recently in North America. Before going on to consider some development and research trends and facilities, we mention features of two of the newer premises that impressed us particularly—the lighting system of Douglas, El Segundo, division's new design offices, and Boeing's extensive flight test hangar at Seattle.

The new design offices of the El Segundo division of the Douglas Aircraft Company, which were brought into use about 18 months ago, have the most effective and pleasing lighting system that we have yet encountered. The drawing offices have a 2 acre open-area translucent ceiling employing some five miles of fluorescent tubing behind corrugated glass, and giving a total of 3,500 deg. K. of light (Fig. 2). This, it is claimed, provides for each drawing board a shadowless light of at least 90 ft. candle. To eliminate sun glare from south-facing windows, vertically-louvred aluminium shades are provided, the openings of which are automatically " solar-controlled " throughout the day.

DOORWAY OPENING 780 FT.

The new flight test hangar at Boeing's Seattle works, put into operation in June, 1954, has the largest unobstructed single doorway in the United States, 780 ft. long and 65 ft. high, with 13 vertical sliding doors each weighing 90,000 lb. The hangar itself, 785 ft. long, 200 ft. wide and 90 ft. high, can easily accommodate five 350,000 lb. B.52 Stratofortress bombers (span 185 ft., length 156 ft., and height 48 ft.) and is, in fact, designed to take future aeroplanes with wing spans up to 300 ft. Fig. 1 shows part of the hangar interior, with a YC-97J flying test bed for Pratt & Whitney T.34 propeller turbines in the foreground, the prototype Boeing 707 jet transport, and in the background a B.52. The hangar also houses the main structural test rig, not visible in the illustration.

The hangar roof, of ribbed steel insulated with Fiberglas and felt roofing material, is of cantilever construction, supported on two trusses resting on two columns in the hangar and tied down to tension columns outside the rear of the hangar. An automatic deluge fire-protection system in 13 sections has its own 400,000 gallon water tanks and pumping station as a safeguard against failure of the city water supply.

The flight test hangar is equipped with a comprehensive radio communications system for liaison between test pilots and flight test engineers on the ground and for receiving telemetered flight test results, as well as for normal air-traffic control liaison. The control room is at roof-top level and two radio transmitter rooms are suspended under the hangar roof close to the aerials; there are 18 transmitters and 26 receivers ranging from 200 kilocycles in the high-frequency band to 400 megacycles in the ultra-high-frequency band, giving coverage over a 250 mile radius.

Adjoining the flight test hangar is a one-storey building housing electronic data-reduction machinery, a photographic laboratory, and an instrumentation laboratory, the equipment for which includes an altitude chamber capable of producing temperatures from − 100 deg. F. to + 180 deg. F., 95 per cent. relative humidity and pressure equivalent to 80,000 ft. altitude.

CONSULTANTS AND COMPUTERS

We turn now to some development and research problems and how they are attacked. Branching out into the fields of supersonic missiles and atomic power projects has introduced research problems normally outside the scope of the aeronautical or mechanical engineer. Convair have tackled this problem by engaging a panel of consultants from among America's most eminent research scientists, covering fluid mechanics and aerodynamics, metallurgy, electronics, mathematical physics, nuclear theory and thermo-nuclear problems, nuclear reactor and weapon design, stellar energy, the upper atmosphere and astrophysics. The panel meets at regular intervals to discuss Convair's problems and to put forward the most advanced ideas in their respective fields.

Within the last few years electronic computers have become a vital tool for the aircraft industry, without which the massive volume of design calculations and test data reduction necessary to develop the supersonic aircraft and missile could not be carried out. The British aircraft manufacturers are well aware of this, and several are developing and using their own machines, but in general they have not the capital available for investing in computing departments on the scale employed in the United States. Every one of the American firms visited is extensively equipped with computers and, usually, operates a specialised computing department for programming and carrying out the work for other departments such as aerodynamics, flight testing, structures, servomechanisms, operations research, accountancy, production, etc.

Analogue computers are extensively employed for investigating the behaviour and stability of automatic control circuits and other mechanisms; they provide a means for quickly assessing the effects of making changes in various parameters. Among the firms who have developed their own analogue computers, Boeing have been notably successful in producing a comparatively low-cost self-contained machine which they have put on the market and which is now in use by a number of other organisations. It provides for general operation, summation, integration, differentiation, simulation of lead, lag, and lead/lag networks, and simulation of a resonant system. There are means for exciting transients and for simulating non-linearities, and an auxiliary servo unit is available for performing multiplication, division, and trigonometric functions.

For data reduction, statistical analysis, structural calculations and in general where complex equations have to be solved, batteries of digital computers are employed; the most ambitious of these, in use at Lockheed, Boeing, General Electric, Douglas, and North American, is the IBM 701, a stored-programme machine of the binary type but able to receive and translate instructions in the decimal system, capable of carrying out up to 14,000 arithmetical operations per second. It has an electrostatic memory unit with a capacity of 2,048 words or numbers of ten decimal digits each, operating through 72 television tubes and, in addition, a magnetic drum memory as well as several (up to 10) magnetic tapes, and incorporates a printing mechanism which can type a line of 120 characters at the rate of 150 lines per minute.

Fig. 2 The Douglas, El Segundo, design office has a 2 acre open-area translucent ceiling. " Solar-controlled " shutters automatically reduce glare from south-facing windows.

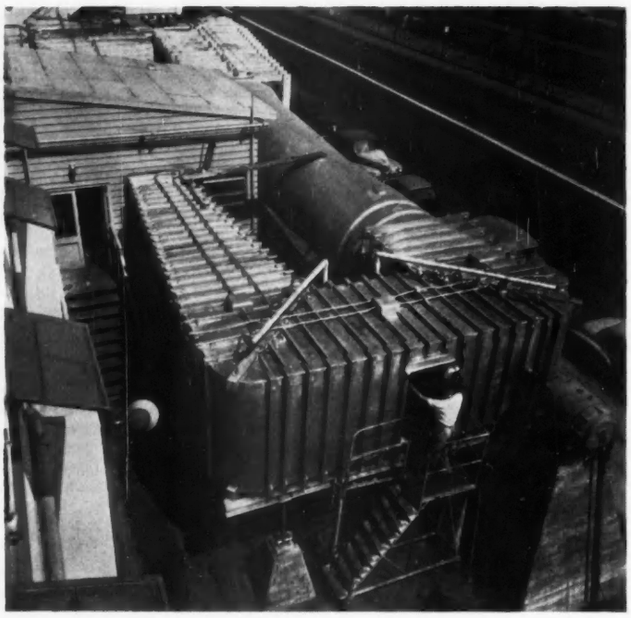


Fig. 3 Outside view of Lockheed icing tunnel, which operates at temperatures down to — 35 deg. F. over a speed range from 15 m.p.h. to 270 m.p.h. Water is sprayed into the chilled air stream to simulate icing conditions.

WIND TUNNELS

Although much of the wind tunnel work of the Californian aircraft firms is carried out in the co-operative research wind tunnel at the California Institute of Technology, Pasadena, North American are operating their own supersonic blow-down tunnels, and Douglas will probably be installing one at Long Beach. North American have also under construction a subsonic-transonic-supersonic tunnel with a 7 ft. square working section, and Convair are to start construction of a 4 ft. square blowdown tunnel next spring which will operate over a speed range from subsonic to Mach 5. The Boeing company, who aim at being autonomous in their test facilities, are in course of constructing a 4 ft. square section blow-down supersonic tunnel, and have in operation a transonic wind tunnel which is almost certainly the largest privately owned facility of its kind.

The Boeing transonic tunnel has a working section 8 ft. high and 12 ft. wide, and for high speed testing it can accommodate models with wing spans up to 9 ft. It was adapted from a high-subsonic closed-circuit tunnel. The working section is vented by elongated slots which allows some of the air at supersonic speed in the test section to escape and expand in a plenum chamber surrounding the test section, thus preventing choking. A development known as "Boeing flaps" are fitted to the walls of the working section downstream where the air expanding through the slots re-enters the tunnel.

Sound-reducing baffles and lining panels have been added to the air intake and exhaust ducts, and the power has been stepped up threefold by the addition of a 36,000 h.p. motor to the original 18,000 h.p. fan motor. The two motors, coupled by a magnetic clutch, drive a two-stage 24 ft. diameter fan, with 36 blades 3 ft. long, in each stage, at 480 r.p.m.

GLASS-CLOTH FAN BLADES

The fan blades are of unusual interest, being constructed of laminated resin-impregnated glass-cloth. Laminated spruce blades previously employed have proved unable to withstand the high operating temperatures of the transonic tunnel, so glass blades have been adopted capable of surviving temperatures of 200 deg. F. Each glass-cloth lamination is 0·014 in. thick; the blade thickness tapers from 56 laminations at the root to eight at the tip. Each blade weighs 50 lb., and is subjected to a centrifugal load of 19 tons when the fan is rotating at high speed.

CLIMATIC RESEARCH

Icing tunnels for studying ice formation and removal on high speed aircraft are in use at the Boeing and at the Lockheed plants. The Boeing icing research tunnel, commissioned this year, provides wind speeds up to 250 m.p.h. at air temperatures down to — 30 deg. F. in a working section 15 in. by 20 in. by 3 ft. long. A water spray is injected into the refrigerated air stream, which is fan-drawn from a "climate room," just before it enters the working section, allowing the simulation of heavy icing conditions.

The Lockheed icing tunnel, an outside view of which is shown in Fig. 3, is rather larger, with a speed range from 15 m.p.h. to 270 m.p.h. and operating at temperatures down to — 35 deg. F. The overall dimensions of the tunnel are 76 ft. long, 26 ft. wide and 27 ft. high; the working section area is 2½ ft. wide by 4 ft. high. The tunnel is powered by a 7 ft. diameter fan driven by a 200 h.p. 1,200 r.p.m. induction motor.

The walls of the tunnel, of $\frac{3}{16}$ in. structural steel plate welded into ten sections and bolted together on site, are reinforced by transverse timber framing. Insulation comprises 4 in. cork on the outside of the walls, protected by a mastic coating.

The refrigerator, with a capacity of 1,200,000 B.Th.U. per hour, comprises a bank of cooling coils arranged in a grid-iron pattern 15 ft. high and 9 ft. wide through which Freon is circulated by three 34 ton compressors. Downstream of the cooling coils nine spray bars introduce water into the chilled air stream. Electrically-heated windows in the working section walls enable the test engineers in the adjacent control room to observe the pattern and rate of ice formation on aircraft and engine components.

Fig. 4 Convair's solar furnace made from a converted anti-aircraft searchlight. It can produce a temperature of more than 7,000 deg. F. at the focal point.

In supersonic flight, the destructive effect of rain can be a limiting factor. Accordingly rain erosion studies are coming to the fore. At Convair rain erosion tests are carried out by mounting test specimens in the nose of a 20 mm. projectile and firing the latter horizontally at speeds up to 1,900 m.p.h. from a standard 20 mm. gun through a curtain of simulated rainfall.

When the gun is fired, a tracer element in the projectile is ignited and burns for about ¾ second. A black powder separation charge then ignites and expels the test specimen and its parachute. The latter, a 6 in. vented canopy nylon parachute, opens at a load of 500 lb. and checks the forward velocity of the specimen within 10 ft. The parachute and specimen land about 1,500 ft. from the firing point. The speed of the projectile is varied within the range Mach 1 to Mach 2·5 by varying the main powder charge.

The rainfall is provided by a 500 ft. pump-fed sprinkling system comprising a single horizontal pipe 3 ft. above the ground, with spray nozzles at 10 ft. intervals. It produces a uniform rate of rainfall of 2 in. per hour with an average raindrop size of 2 mm. diameter.

For testing the effects of extreme temperatures on aircraft systems and components Convair have recently brought into operation what is believed to be the largest wide-range temperature chamber on the western coast of America, 20 ft. long by 10 ft. wide by 10 ft. high and capable of holding full-scale test sections of aircraft. The temperature range is from — 100 deg. F. to + 300 deg. F., and it is possible to change from one extreme to the other within four hours.

The refrigeration system is of the direct control type using liquid carbon dioxide forced through commercial alcohol; the carbon dioxide being stored at a pressure of 300 lb. per square inch and a temperature of 0 deg. F. in a 6 ton tank. The alcohol, at — 112 deg. F., is pumped through ¾ in. finned copper tubing located in the rear wall of the chamber. Air is fan-circulated over the finned tubing and through the chamber to cool the test specimens.

The heating system comprises 60,000 watt resistance heating elements. The heat exchanger also is located in the rear wall. For tests requiring hot liquids, a 100 gallon tank supplies pressurised water or steam up to 300 deg. F. The relative humidity can be controlled over the range 50 per cent. (at 77 deg. dry bulb) to 95 per cent. The interior of the chamber is of stainless steel sheet, and the floor is covered with a scuff-proof spark-resistant material. The 8 in. chamber walls are insulated with glass wool. Observers can enter the chamber during tests through an air lock, and tests can be observed from outside through a "thermopane" window.

SOLAR FURNACES FROM CONVERTED SEARCHLIGHTS

Heat-transfer problems and high-temperature research are among the primary studies occupying the American firms. In this field Convair have equipment of unusual interest; for testing the behaviour of metals, plastics, ceramics and other materials at high temperatures, they are using solar furnaces. One of these, a 120 in. furnace, has been in use for about 18 months. Two others have recently been brought into use, adapted from 60 in. war-surplus anti-aircraft searchlights acquired this year for only 400 dols. each (Fig. 4). A third 60 in. searchlight has been kept intact to provide a source of heat energy which can be used when sunlight is not available. The energy produced by this searchlight is about 60 per cent. of that received from the sun's radiation.

The searchlights were converted into solar furnaces by removing the arc-lighting mechanisms and glass covers. A drill chuck serving as a specimen holder was installed in each, and adjustment handles were attached for moving the test samples into and out of the focal point. The polished metal surfaces of the searchlight mirror concentrate the sun's rays to the focal point, which is 0·3 in. diameter, and are capable of producing temperatures of more than 7,000

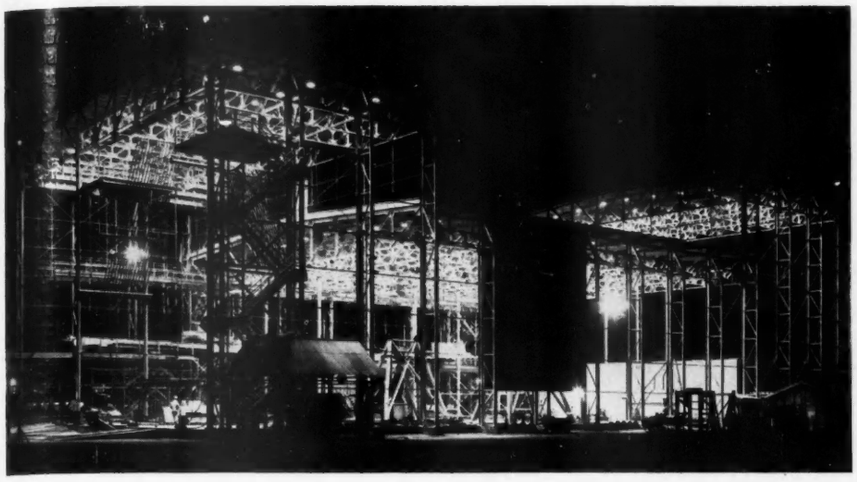


Fig. 5 Convair's static structural test rig at night, designed specifically for proving large flying boat structures, with a load capacity up to 1,000,000 lb. in any direction.

deg. F. These 60 in. solar furnaces have, in fact, been found to give higher temperatures than the 120 in. furnace because their smaller mirrors have a more nearly parabolic curve than the larger mirror and their surfaces are more highly polished. The 120 in. furnace, however, has certain refinements—the amount of sunlight shining on the mirror can be controlled to regulate the heat applied to a specimen, and it has an observatory-type timing mechanism which keeps the sun in focus as the earth moves. A similar automatic sun-tracking mechanism is being developed for the new furnaces.

HYDRODYNAMICS

The work of the Convair hydrodynamics research laboratory on self-propelled radio-controlled dynamically-similar free-flight flying boat models, and the emancipation of the configuration of the water-based aircraft to which these investigations have led, was well described by Mr. Ernest G. Stout in a paper presented at the 1951 Anglo-American aeronautical conference, reported in the October 5 and 12 issues of ENGINEERING (vol. 172, pages 441, 478). The water-based experimental supersonic delta-wing fighter, the F2Y Sea Dart, that is, to date, the ultimate outcome of these notable investigations, is still under evaluation.

The hydrodynamics laboratory is to be further strengthened by the addition of model sea-plane towing basins. The installation is to comprise two 300 ft. towing basins, a 100 ft. square turning basin, and an office structure. The long tanks are to be 6 ft. deep and 12 ft. wide, and will be concrete lined. Fresh water will be used. An overhead monorail will extend over the length of the towing tanks. The square tank will be equipped with wave-making equipment.

It is intended to use the long tanks not only for hull-form research, etc., but also for underwater ballistic studies and for investigating supersonic aircraft shapes using water as the test fluid instead of air.

STRUCTURE TESTS

The static structural test rig at Convair's San Diego plant is an imposing structure (Fig. 5), believed to be the largest in use in the aircraft industry, and designed specifically for testing the strength of naval flying boats. The steel framework is carried on a 3 ft. reinforced-concrete foundation 196 ft. long by 100 ft. wide. The maximum height of the test frame is 67 ft., with ceiling heights of 56 ft. in one bay and 35 ft. in another. Weather protection is provided by Plastiglass sidewalls.

The hydraulic loading equipment can apply loads ranging from 60,000 lb. to 1,000,000 lb., in any direction. These loads can be subdivided between 200 application points. The loading system is regulated and the deflections and strain gauge readings are recorded in a separate building.

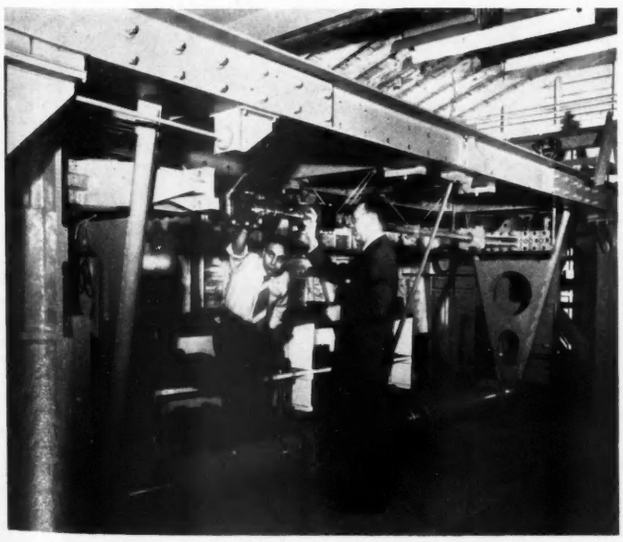


Fig. 6 Lockheed's "big bruiser" for testing aircraft components under repeated impact loading up to 500,000 lb. at 2,000 cycles a minute.

Since Lockheed are one of the firms who design and construct their own landing gear, their test facilities include a large undercarriage drop-test rig and a "shimmy" test rig. The latter comprises a 3 metre rotating drum against which the landing gear, heavily weighted, is held in place to determine whether the wheel will develope shimmy in service.

An interesting piece of strength-testing equipment developed by Lockheed is the "Big Bruiser" illustrated in Fig. 6, in which aircraft components are subjected to a repeated impact load of 500,000 lb. The load is applied by a horizontal hydraulic jack and an unbalanced weight, enclosed in the steel structure on the left, which set up vibrations up to 2,000 cycles per minute in steel masses between which the test component (in the illustration, an undercarriage piston in high-heat-treat steel) is held.

ROCKET TEST STAND

The North American Aviation Company, who are probably the principal pioneers in developing large rocket motors for long-range guided missiles (up to 50,000 lb. thrust has been announced), recently reached an agreement with Rolls-Royce Limited under which the latter company is licensed to manufacture rocket propulsion systems designed and developed by North American. These systems are developed at the extensively-equipped Propulsion Field Laboratory in the Santa Susana mountains; here also is being built the sodium-graphite reactor for the Atomic Energy Commission which is due to be in full operation early next year.

Among the facilities at Santa Susana is the static test stand illustrated in Fig. 7, in which rocket thrust is determined; an outdoor component tests laboratory in which pumps, turbines, generators, regulators and control equipment are tested and cold-calibration tests of complete rockets are carried out; an enclosed free-flight duct where small rockets are launched under simulated flight conditions; a fuel test laboratory; and a reinforced concrete blockhouse from which the cold calibration and static test runs are automatically recorded. Unfortunately, we are not permitted to publish any technical details of this impressive plant. North American's rocket engineering resources will be further strengthened by a new propulsion development centre recently opened some 10 miles distant from Santa Susana at Canoga Park, California.

RAM-JET TEST CHAMBER

In June this year the Curtiss-Wright Corporation added to their existing ram-jet test facilities a new supersonic high-altitude test chamber for developing and production-testing ram-jet engines, a field in which they are well advanced for large missile applications. The new chamber, 14 ft. in diameter and 96 ft. long, is adjacent to an older and smaller test chamber, and is connected to it by Y joints so that a common air supply and exhaust system can serve both units. A general view of the facility is given in Fig. 8. The older test chamber, 12 ft. in diameter and 60 ft. long, provides "altitudes" up to 80,000 ft.

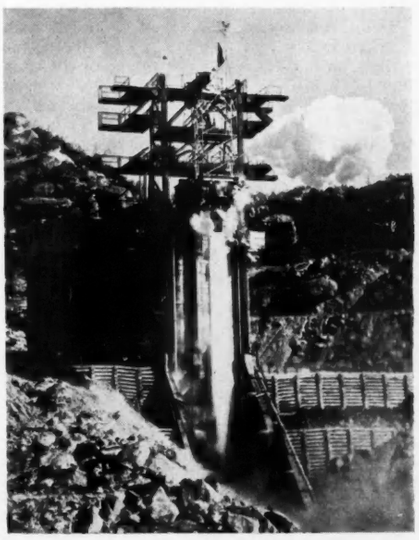


Fig. 7 Static test stand for determining rocket thrust at North American's Santa Susana laboratory. Rockets up to 50,000 lb. have been developed by North American.

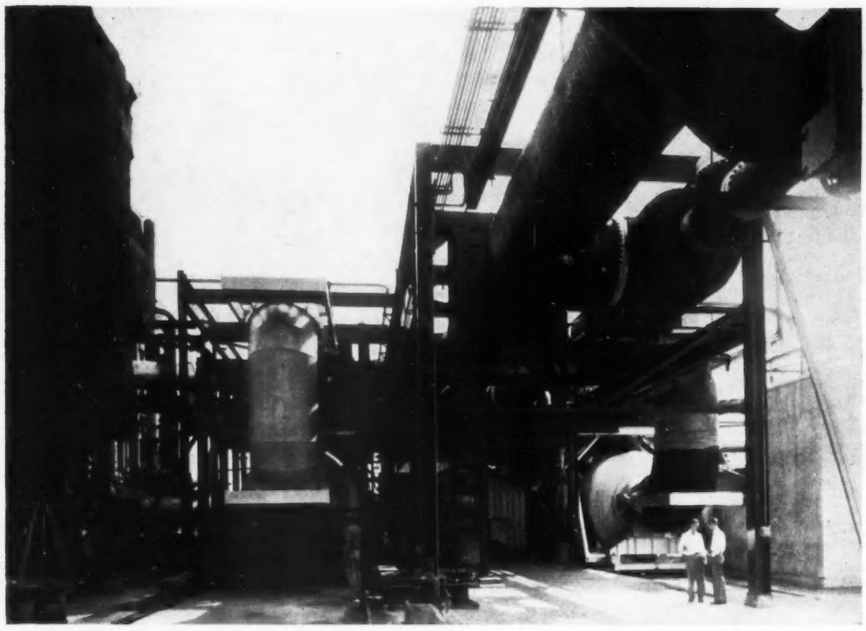


Fig. 8 General view of the Curtiss-Wright ram-jet test facility. There are two test stands, the older one, 12 ft. in diameter and 60 ft. long, providing speeds up to 2,600 m.p.h. and altitudes up to 80,000 ft. The new stand is 14 ft. in diameter and 96 ft. long ; performance not disclosed.

and speeds up to 2,600 m.p.h.; the higher performance of the new chamber has not been disclosed. A new control room has been built serving both test stands and, as seems general practice in the United States, much of the instrumentation is automatic and recordings can be fed directly to digital computers for data reduction. For observing the engine during test runs, a submarine type of periscope has been built into the new chamber.

The new test chamber, which is mounted on coil springs and anchored to a massive concrete footing, comprises a surge chamber 15 ft. long that rolls away from the main tank on rails, a supersonic nozzle section 18 ft. long, a main chamber, and the exhaust end. The nozzle proper, which is 27 ft. long, overhangs both ends of the section in which it is located. It is of the variable Mach-number type and can be changed from Mach 1·5 to a series of higher speeds.

Both free-stream and ducted testing are possible in the new test stand. In free-stream testing, air is flowed past the engine or the component on test. This most nearly approximates to actual flight conditions. In ducted testing the air is piped to the engine and away from it so that the inlet and exhaust of the engine are integral with and connected to the air and exhaust ducts.

The test chamber can be operated steadily for more than one hour, or alternatively it can be used as a blow-down tunnel to give an extremely high airflow—as much as 70 lb. per second for relatively short periods. A steady airflow is provided by an electrically-driven compressor absorbing 17,000 h.p. Backing up this compressor for providing substantially higher pressures for intermittent operation are air storage bottles with a total capacity of 43,000 lb. of usable air at 3,200 lb. per square inch. A side hatch, 36 ft. long, is raised to admit the test engine or combustion rig.

To reduce noise and keep the intense combustion temperatures from reaching the outside of the tank, the test chamber is water-jacketed over its entire length, the water flowing between two steel shells 1 in. thick. The side hatch also contains water between its inner and outer shells. Flexible hoses connect this water to the tank's outer cooling system.

To achieve the simulation of altitude a series of nine steam ejectors have been installed that will reduce pressure inside the test chamber by evacuation. The maximum altitude that can be reached cannot be disclosed.

Four of these ejectors are 24 in. in diameter and require 75,000 lb. of steam per hour each to operate. Two others, 42 in. in diameter, require steam at the rate of 300,000 lb. per hour each; these are intended for blow-down runs, as are also the remaining three which measure 48 in. in diameter, the largest steam ejectors ever fabricated. They each require steam at the rate of 400,000 lb. per hour. To supplement the plant boiler house which can supply up to 300,000 lb. of steam per hour at 140 lb. per square inch, four package boilers have been installed to supply a total of 120,000 lb. per hour. An extra 245,000 lb. of usable steam that they generate can be stored in seven accumulator tanks at 500 lb. per square inch.

The temperature of the ram-jet exhaust gases may be as much as 3,500 deg. F. A direct water spray is mixed with the gases at once as they travel downstream away from the engine or combustion rig on test, so that the temperature of the hot gases is reduced within a few feet of travel to approximately 800 deg. F. By the time the exhaust product has reached the end of the exhaust gas cooler the temperature has dropped to about 100 deg. F. By this time much of the cooling water, instantly converted to steam at the outset, has been condensed again to liquid form and can be recovered. The cooled gases continue through a silencer.

Cooling water is drawn from a two-million gallon reservoir adjacent to the exhaust-gas cooler. Standing about 73 ft. high, this tank can deliver water at the rate of 30,000 gallons per minute.

As the water is condensed again from steam and recovered, it travels to a cooling tower and a settling basin where impurities and dirt are separated. Cleaned water is then pumped back into the main tank for re-use.

The new laboratory contains three heaters capable of heating air for test purposes to temperatures experienced in supersonic flight at high levels. An older unit, used for continuous flow testing in the original test stand, remains; but a new continuous flow heater of much larger size to conform to the increased air flows now possible has been installed.

The most interesting unit from the standpoint of design is the intermittent air heater, capable of heating air released from storage bottles at 70 deg. F. to 800 deg. F. Relatively small in diameter but 90 ft. long, the heater is cylindrical in shape and contains a large amount of stainless tubing which carries the heat. It takes approximately eight hours to reach the required temperature.

TESTING TURBOJETS AT "ALTITUDE"

At Pratt & Whitney Aircraft three large altitude chambers are installed in their extensively-equipped Andrew Willgoos Turbine Laboratory at East Hartford, in which full-scale engines can be tested under the temperature and density conditions obtaining at high altitudes. In Fig. 9 a J.57 turbojet is seen installed in one of the chambers; it will be observed that the entire side of the chamber swings up to provide accessibility.

Automatic electronic plotting techniques are widely used for reducing test cell results. The Pratt & Whitney Aircraft Plottomat machine receives the various pressure, temperature, and flow direction signals from the test cell and reduces them to graphical form. Simultaneously, digital instrumentation records the actual numerical readings and feeds them to an I.B.M. machine to be punched on cards. The sensing instruments used are principally resistance strain

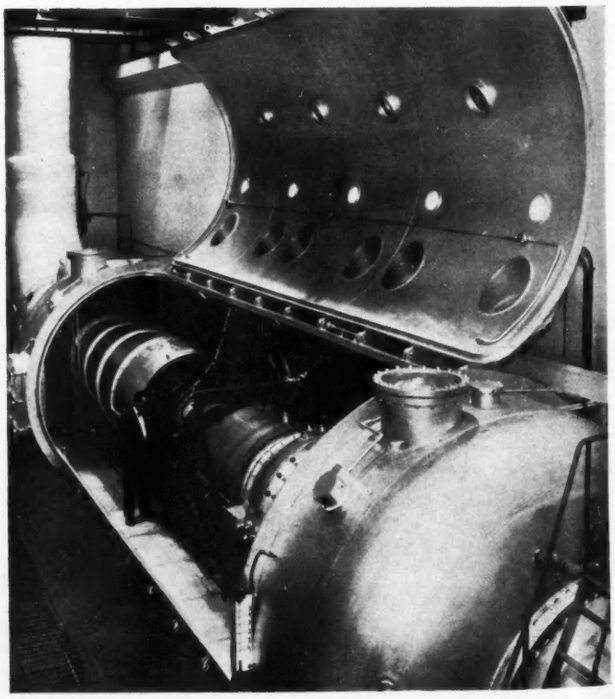


Fig. 9 A J.57 turbo-jet engine installed in one of the three altitude test cells at Pratt & Whitney Aircraft's Willgoos turbine laboratory at East Hartford.

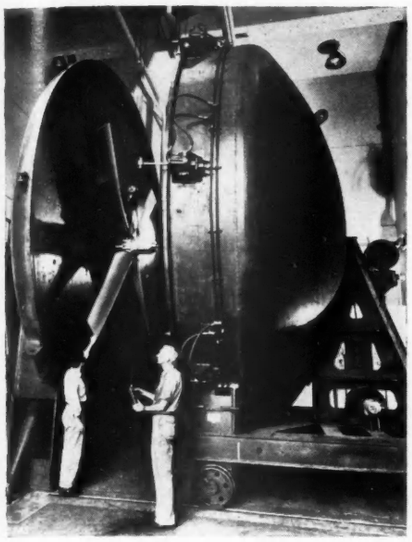


Fig. 10 Propellers are dynamically balanced in a 20 ft. diameter evacuated clamshell at Hamilton Standard's laboratories, at simulated altitudes up to 100,000 ft.

gauges. Where it is impractical to use a connecting wire, use is being made of transistor tubes which send out a signal without wiring.

The research facilities of the General Electric Company also include, among a comprehensive range of component and engine test rigs, an altitude test cell for full-scale turbojets capable of reproducing density conditions appropriate to an altitude of 75,000 ft. and temperatures from − 67 deg. to + 200 deg. F.; and a full-scale compressor test stand capable of simulating altitudes up to 70,000 ft. at temperatures down to − 100 deg. F. A 33,000 h.p. tandem steam turbine drives the test compressor.

PROPELLER TESTING

One of the most up-to-date of the test facilities is that of the Hamilton Standard Division of United Aircraft Corporation, comprising a test building of about 60,000 sq. ft. floor area containing two propeller test cells, a test cell for testing the Division's fuel controls and starters on afterburning jet engines, up to 25,000 lb. thrust, a pneumatic laboratory including a 2,500 cub. ft. altitude chamber, a fuel control laboratory and a propeller balancing room; within the factory itself a hydraulics and mechanical testing laboratory, a vibration laboratory, and an electronics laboratory; and a separate building housing a combustion laboratory for testing combustion-type starters, equipped with four explosion-proof test chambers, one of which contains a 6 ft. diameter whirl pit for overspeed destructive testing.

In the hydraulics and mechanical test laboratory are four whirl rigs, each driven by a reciprocating engine, housed in separate rooms, for whirling propeller hub and control mechanisms incorporating stub blades or counterweights to simulate flight conditions. One of these rigs allows tests to be carried out at temperatures up to 200 deg. F., and is equipped with apparatus for testing water and stone erosion. The laboratory also includes a cold room in which stub-blade propellers can be whirled at temperatures down to − 100 deg. F. Refrigeration is supplied by a three-stage Freon system of about 200 tons capacity.

The two propeller test cells are designed to accommodate engines up to 20,000 h.p. Incorporated in each test cell is an adjustable cone-type orifice which may be placed in front of any propeller up to 28 ft. in diameter to provide a uniform airflow. In another part of the test building, propeller dynamic and aerodynamic unbalance is measured. Here, a Gisholt dynetric balancing machine drives a full-scale propeller in an evacuated "clamshell" 20 ft. in diameter (Fig. 10). The pressure within the clamshell can be reduced to simulate an altitude of approximately 100,000 ft. Under such conditions any aerodynamic unbalance may be eliminated, and thus the relative magnitudes of dynamic and aerodynamic unbalance determined. Also, the propeller can be operated at the rotational speeds and blade angles which are normally associated with flight conditions without consuming excessive power.

(The third and fourth articles will appear in subsequent issues)

DEFLECTIONS AND VIBRATIONS OF DRILLING MACHINES

REQUIREMENTS FOR IMPROVED OPERATION

Two experimental investigations were described in papers read to the Institution of Mechanical Engineers on December 3. Dr. D. F. Galloway, in his paper entitled "Some Experiments on the Deflections and Vibrations of Drilling Machines," gave details of some work which is part of a series of researches being carried out to obtain data for improving the design, construction and utilisation of production equipment, having regard to the increasing demand which will result from the growth of automation. The second paper, "The Vibrations of Radial Drilling Machines under Test and Working Conditions," by Dr. S. A. Tobias and Professor W. Fishwick, was in three parts, dealing with vibration under test conditions, vibration under working conditions, and the theory of drilling chatter.

Dr. Galloway carried out experiments on nine machines; five radial, two vertical, and two specially-constructed portal-frame machines. Observations were made of the deflections and displacements of the machine heads, arms, columns, tables, frames and bases, measurements being taken by dial gauges fitted on rigid stands. Vibrations were recorded with the machines running light, during a complete drilling cycle, and in facing operations.

The tests, which were too extensive to be described here, provided valuable data, and enabled a number of conclusions to be drawn. It was shown that the total deflection and change of slope of the heads and arms of radial drilling machines arose mainly from deflections in the columns and bases. Deflections of the arms themselves were relatively small. Drilling machine users can minimise deflections by reducing to a minimum the height of the arm on the column and the distance between the head and the column, and by clamping the arm and head securely.

Changes in design and construction which would improve the deflection characteristics of radial drilling machines include: more rigid bases adequately bolted to a sound foundation, and in some cases more robust column-flange construction; stiffer columns; outer ties for the arms, thus converting radial machines into the portal-frame type; adequate and easily-operated clamps. Column stiffness-weight ratio can sometimes be increased by eliminating stiffening ribs from the column and redistributing the metal uniformly round the column wall; this arrangement may necessitate extra care to avoid unsound castings. Movements under load tended to correct the initial misalignment between bases and radial arms of radial drilling machines, but these movements varied with the thrust load and the initial misalignments were correct only for a particular load. Deliberate misalignment of a machine involves a compromise which results in some misalignment with different thrusts. Design improvements based on complete analysis of deflections increase rigidity and reduce the need for initial misalignments.

The largest movements on vertical drilling machines were due to the bending of the column above the table; the need for increased column-stiffness is indicated. The smallest deflections measured were on the portal-frame machines. They were very small indeed compared with those of radial machines, and were almost symmetrical in occurrence.

Measurements of vibrations showed that, owing to the low damping capacity of the machine structure in the first mode of vibration, large amplitudes of vibration occurred when a small periodic force was applied to the drill heads of the radial machines at frequencies close to the first natural frequency of the machine. The vibration stability of radial machines deteriorated rapidly as the drill head was moved away from the column and as the arm was raised. Forced vibrations set up in the radial machines by drill-head motors and other rotating parts were generally small compared with the vibrations induced by drilling and facing operations. A tuned and damped vibration absorber was able to reduce greatly the amplitudes of vibration in radial machines during spot-facing.

TEST AND WORKING CONDITIONS

Dr. Tobias and Professor Fishwick carried out their experiments on two radial machines which were not known to chatter under normal workshop conditions, though it was known that other machines, of basically similar design, were not so satisfactory. It was shown that even with machines which are liable to chatter vibration-free drilling can be achieved by suitable drilling speeds and other working conditions.

The investigations yielded information concerning the designers of machine tools and drills, and the users of machine tools. The essential conclusion from the point of view of the machine designer is that the danger of chatter is eliminated, or at least reduced, by great dynamic stiffness and high damping. The latter factor, unfortunately, is almost entirely beyond the designer's control, since it appears to be determined mainly by the nature of the foundations. Little is known about the damping capacity of various types of foundation, and the development of foundations with a very high inherent damping is likely to be an attractive field of research. The avoidance of unstable drilling speeds is of primary importance.

The drill designer will find that it is desirable for a drill to have a thrust-against-feed curve which is convex from below. Total thrust as such does not enter the theory and its reduction is advantageous as long as the above condition is satisfied. In general a reduction of the chisel-edge length makes the drill more liable to chatter, particularly with drills of large diameter which drill at high feeds. It is widely believed that chatter at break-through is due to the sudden release of flexural energy stored in the structure. This has been shown to be of only secondary importance, the main cause being the absence of the stabilising effect of the chisel edge.

The user of a radial drilling machine is advised to ensure that it is bolted to a stiff foundation. It is preferable to drill with relatively high feeds when drilling into the solid, but opening up the best conditions are small feeds with a drill having a small helix angle. In both cases the arm should be in the lowest possible position and the saddle as near to the column as possible. If, in spite of these precautions, chatter occurs, the first remedy lies in an alteration of the drilling speed. When drilling into solid the speed should be decreased and the feed increased; in opening up the opposite procedure is advised.

BOLTING MATERIALS FOR HIGH-TEMPERATURE STEAM-PLANT SERVICE

By M. G. Gemmill and J. D. Murray**

The continual increase in the operating temperatures of steam plant has been reflected in the development of steels for tubes and piping capable of operating at metal temperatures of 1,050 deg. F. for 100,000 hours. While bolted pipe joints are being eliminated as far as possible in high-temperature installations bolts will continue to be required for such components as turbine casings. These materials must have adequate creep resistance at these higher operating temperatures and this demand has led to the development in recent years of steels capable of being used above 900 deg. F.; up to this temperature complete satisfaction has been given by Durehete 900, a steel of the En. 20 or 1 per cent. Cr-Mo type. For service above 900 deg. F. it is necessary to use more creep-resistant materials and the object of this article is to outline some recent developments in this connection. For this purpose the article is divided into three parts, dealing firstly with the properties of a 1 per cent. Cr-Mo-V steel, Durehete 950, developed directly from Durehete 900 by the addition of 0·25 per cent. vanadium; secondly, giving a more detailed study of the effects of carbon, molybdenum and vanadium upon the high temperature strength of this type of material; and thirdly, with the properties of a steel formulated from this systematic work for long-time service at temperatures up to 1,050 deg. F.

DUREHETE 950

As mentioned above, this composition was directly developed from Durehete 900 and typical analyses of these two qualities are:—

Quality	C	Mn	Si	Cr	Mo	V
Durehete 900 ..	0·42	0·58	0·25	1·29	0·59	—
Durehete 950 ..	0·39	0·50	0·20	1·28	0·65	0·26

Laboratory work, both tensile and impact tests at room temperature and constant strain stress-relaxation tests† at 950 deg. F., have shown that solution temperatures above 950 deg. C., often required to ensure full benefit from vanadium-bearing steels, were not markedly beneficial in the case of this particular composition. In consequence the heat treatment recommended for this steel is heating to 930/960 deg. C., then oil-quenching and finally tempering to 600/700 deg. C., depending upon the tensile-strength requirement.

To confirm its suitability as a bolt steel the mechanical and high-temperature strength properties were assessed with the results given in Table I—mechanical properties, and Table II—stress relaxation properties. This information refers to 1¼ in. diameter bar; since turbine-casing bolts are frequently of much larger dimension it is of interest to record results obtained on 4¼ in. diameter bar material. The impact resistance after exposures for times up to 3,000 hours at 900 deg. F. is given in Table III and stress-relaxation properties are compared with those of 1¼ in. diameter bar in Table IV. This information illustrates the reproducibility of properties obtained in large-section sizes and shows the good resistance to embrittlement of this quality. The stress-relaxation results demonstrate that 950 deg. F. represents the highest temperature at which this composition is suitable for bolting. Its high-temperature strength, relative to the already mentioned Durehete 900 quality and to a subsequently-developed material will be discussed later in this article.

1 PER CENT. Cr-Mo-V STEELS

While the addition of 0·25 per cent. vanadium to an established composition, as in the instance of Durehete 950, proved a successful means of increasing the upper service-temperature limit from 900 deg. to 950 deg. F. it was realised that to obtain further improvement in the creep resistance of steels of this type demanded a more systematic approach. The target set was to extend the range of service from 950 deg. to 1,050 deg. F. and the procedure adopted was to examine, separately and together, the influence of carbon, molybdenum and vanadium upon the properties of 1 per cent. chromium steels and from the results to derive, if possible, a suitable composition.

EXPERIMENTAL PROCEDURE AND RESULTS

The development work was carried out on 24 steels made in an 18 lb. spark-gap furnace. The ingots were forged to 1 in. and ⅝ in. diameter bar, the former being used for creep tests, the

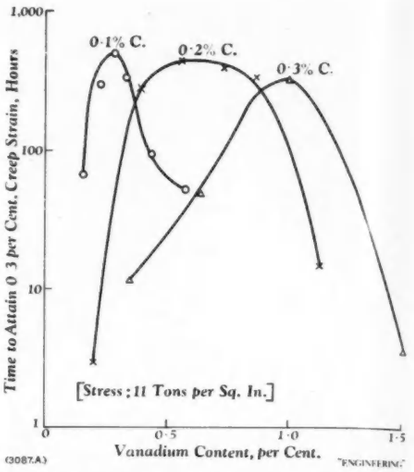


Fig. 1 The effect of carbon and vanadium on the creep strength at 1,112 deg. F. (600 deg. C.).

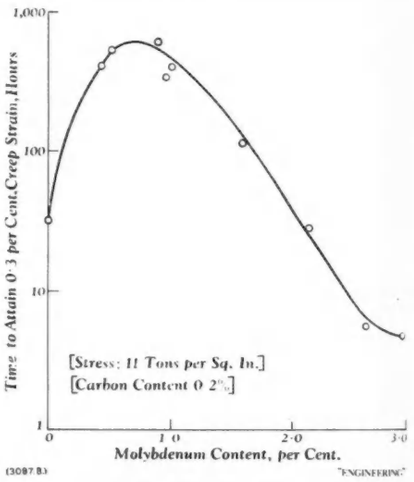


Fig. 2 The effect of molybdenum on the creep at 1,112 deg. F. (600 deg. C.).

TABLE I.—DUREHETE 950—MECHANICAL PROPERTIES

Heat treatment: Oil-quenched from 950 deg. C.; tempered at 690 deg. C. for 2 hours, then air cooled. 1¼ in. diameter bar.

Test temperature deg. F.	Test temperature deg. C.	Ultimate tensile stress, tons per sq. in.	0·1 per cent. proof stress, tons per sq. in.	Limit of proportionality, tons per sq. in.	Elongation, $4\sqrt{a}$, per cent.	Reduction of area, per cent.	Izod impact, ft. lb.	Modulus of elasticity, tons per sq. in.
68	20	64·2	60·3	54·0	25·5	64	75	13,800
900	482	47·5	36·4	15·6	27·5	73	38	11,500
950	510	44·8	32·7	9·9	29·0	76	41	11,300
1,000	538	41·3	28·0	9·2	33·5	79	32	11,100

TABLE II.—DUREHETE 950—STRESS-RELAXATION PROPERTIES

Heat Treatment: Oil-quenched from 950 deg. C.; tempered at 690 deg. C. for 2 hours, then air-cooled. 1¼ in. diameter bar

Test temperature, deg. F.	900	950	1,000	1,050
deg. C.	482	510	538	566

Initial stress 14 tons per square inch

Residual stress, tons per sq. in. at (hours)	1st load application	2nd load application	1st load application	2nd load application	1st load application	1st load application
1	13·00	13·75	12·80	13·35	12·20	10·55
10	12·25	13·45	11·65	12·70	9·50	7·45
100	11·00	12·90	9·65	11·30	6·85	4·45
300	10·05	—	9·00	—	5·10	3·10
1,000	9·20	—	7·95	—	3·30	2·10

TABLE III.—*Durehete* 950—*Resistance to Embrittlement.*

Heat Treatment: Air-cooled from a temperature of 950 deg. C.; reheated to 950 deg. C then oil-quenched, tempered at 690 deg. C. for 2 hours and finally oil-quenched. 4¼ in. diameter bar.

Position of specimens in bar	As heat treated	After 1,000 hours at 900 deg. F. (482 deg. C.)	After 2,000 hours at 900 deg. F. (482 deg. C.)	After 3,000 hours at 900 deg. F. (482 deg. C.)
	Izod impact values in ft. lb.			
Centre ..	73	44	38	41
Midway	75	38	50	38
Edge ..	75	72	71	71

TABLE IV.—*Durehete* 950—*Stress-Relaxation Properties*

Comparison of 1¼ in. and 4¼ in. diameter bar.
Initial Stress: 14 tons per square inch. Temperature 950 deg. F. (510 deg.C.)

Bar diameter (inches)	1¼ in.	4¼ in.
Residual stress, at tons per sq. in., 1 hour	12·80	13·00
10 hours	11·65	12·00
100 ,,	9·65	10·55
200 ,,	9·20	10·05
300 ,,	9·00	9·65
400 ,,	8·80	9·30
500 ,,	8·60	9·00
1,000 ,,	7·95	8·00
2,000 ,,	—	6·90
3,000 ,,	—	6·25
4,000 ,,	—	5·70
5,000 ,,	—	5·20
Heat treatment	As shown in Tables I and II	As shown in Table III.

* Research and Development Department, The United Steel Companies, Limited, Swinden Laboratories, Moorgate, Rotherham.

† See Appendix on page 827.

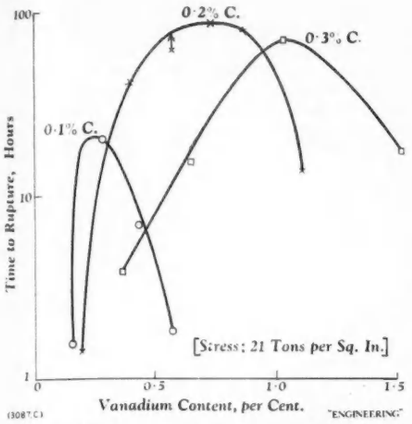


Fig. 3 The effect of carbon and vanadium on the rupture strength at 1,112 deg. F. (600 deg. C.).

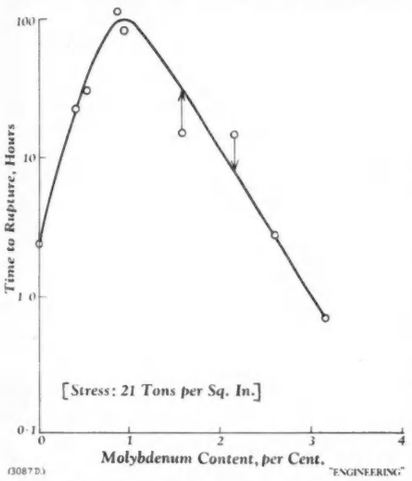


Fig. 4 The effect of molybdenum on the rupture strength at 1,112 deg. F. (600 deg. C.).

latter for all other tests. The percentage analyses of these steels were as follows :—

Steels Nos. 1 to 6 were of the 0·10 carbon, 0·4 manganese, 0·2 silicon, 1·0 chromium, 1·0 molybdenum type and the vanadium content ranged from 0·16 to 0·57, so as to give a vanadium : carbon ratio of from 1·57 to 5·75.

Steels Nos. 7 to 12 differed from Nos. 1 to 6 in having 0·2 carbon, with a vanadium : carbon ratio varying from 0·91 to 5·05.

Similarly, steels Nos. 13 to 16 had carbon of 0·3 and a vanadium : carbon ratio ranging from 1·27 to 5·41.

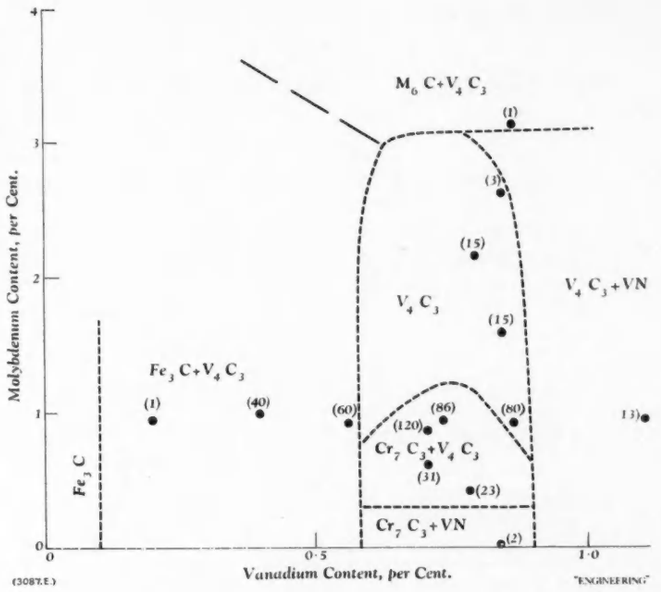
Steels Nos. 17 to 24 contained 0·2 carbon, 1·0 chromium, with the 0·4 manganese, 0·2 silicon additions, and a constant vanadium : carbon ratio of 4·0. In this last batch of steels, however, the molybdenum content ranged from 0 to 3·15.

(i) *Heat Treatment.*—All the steels were oil quenched from 1,050 deg. C. and tempered for nine hours at 700 deg. C.; this treatment was based upon the maximum hardening and grain-coarsening characteristics of the 0·2 per cent. carbon steels. The maximum hardening temperature increased with vanadium content; grain coarsening did not occur in any of the steels containing up to 1 per cent. molybdenum for solution temperatures up to 1,050 deg. C.

(ii) *Mechanical Properties.*—The room-temperature mechanical properties were determined for each steel, the results being given in Table V.

(iii) *Creep Resistance.*—An arbitrary test condition, namely, 11 tons per square inch at 1,112 deg. F. (600 deg. C.) was selected to assess the various steels. The time to attain 0·3 per cent. creep strain under these circumstances is shown in Fig. 1 as a function of the carbon and vanadium contents (steels 1 to 16 inclusive) and in Fig. 2 as a function of the molybdenum content (steels Nos. 10, 11 and 17 to 24 inclusive).

Fig. 5 The relationship between carbide constitution and rupture strength at 1,112 deg. F. (600 deg. C.) of 0·2 per cent. carbon, 1 per cent. chromium steels containing molybdenum and vanadium. The test conditions are 21 tons per square inch and the rupture life in hours is shown in brackets.



(iv) *Rupture Strength.*—The rupture strength was assessed by a test at 1,112 deg. F. (600 deg. C.) under a stress of 21 tons per square inch. The results obtained are related to the composition variables in Fig. 3 for steels Nos. 1 to 16 inclusive and in Fig. 4 for steels Nos. 11 and 17 to 24 inclusive.

(v) *Phase Identification.*—X-ray examination was made of electrolytically-separated residues obtained from selected steels in the solution-treated and fully heat-treated conditions as well as after creep testing, this information forming the basis of a carbide constitution diagram, for these steels, as shown in Fig. 5.

DISCUSSION OF RESULTS

While the creep resistance of a steel is primarily a function of its chemical composition, the manner in which the individual alloying elements can influence this property is not always direct. In the case of ferritic steels having microstructures of ferrite and transformation product, an alloying element could alter both the proportions and nature of these components. In steels of the type considered in this article which have a fully transformed and tempered microstructure, the influence of alloying elements is visually less obvious. In both instances, however, one has to bear in mind the possible further effect of alloy carbides, formed either during cooling from the austenitic region or upon subsequent tempering. It is reasonable to suppose that creep strength is influenced by all these factors thus making it difficult to determine the influence of a single element upon the creep resistance, more so when the test method might affect the results obtained.

Both the low deformation creep resistance and the rupture strength are influenced by the vanadium and molybdenum contents. Comparison of the mechanical properties, Table V, creep resistance, Fig. 1, and rupture strength, Fig. 3, shows that for each carbon content there is a vanadium content giving optimum properties. A similar conclusion can be drawn regarding the effect of molybdenum content upon the properties of 0·2 per cent. carbon, 0·8 per cent. vanadium steels, as is shown in Figs. 2 and 4.

It has been found most convenient to seek an explanation of these effects in terms of the carbides present in the various steels. This has been attempted in Fig. 5, which depicts the carbide constitution of the 0·2 per cent. carbon steels in relation to their rupture strength at 1,112 deg. F. (600 deg. C.). The test conditions are 21 tons per square inch, and the rupture life, in hours, is shown in brackets. It will be noted that for the 1 per cent. molybdenum steels the best creep resistance appears to be associated with the V_4C_3-phase region where it adjoins other phase regions. From this it might be implied that the best high-temperature strength is due not only to the presence of one strong

TABLE V.—*Mechanical Properties of Experimental Steels.*
Heat Treatmem: Oil quenched from 1,050 deg. C.; tempered at 700 deg. C. for 9 hours.

Steel No.	Ultimate tensile stress, tons per sq. in.	Yield stress, tons per sq. in.	Izod impact value, ft. lb. Average
1	46·6	41·4	91
2	47·4	41·5	85
3	50·0	45·0	82
4	49·7	43·9	82
5	50·0	44·3	86
6	48·7	43·1	84
7	52·3	45·2	90
8	59·0	53·2	73
9	62·1	56·2	66
10	62·5	57·0	69
11	64·8	59·2	74
12	57·5	48·8	69
13	63·2	56·5	74
14	60·2	52·5	69
15	62·9	59·4	76
16	56·1	52·9	84
17	59·4	53·4	42
18	63·5	59·0	79
20	61·9	56·5	71
21	61·8	53·0	67
22	59·8	50·6	68
23	56·8	49·3	60
24	51·8	43·7	64

The elongation values on $4\sqrt{A}$ range from 20·8 to 31·4 per cent. and the reduction of area values from 51·4 to 72·6 per cent. The Izod values shown are the average of 3 tests.

TABLE VI.—CAST A: 1 CR., 1 MO, 0·8 V STEEL—MECHANICAL PROPERTIES
Heat treatment: Oil-quenched from 1,050 deg. C.; tempered at 700 deg. C. for 9 hours. 1½ in. diameter bar.

Test temperature		Ultimate tensile stress, tons per sq. in.	0·1 per cent. proof stress, tons per sq. in.	Limit of proportionality, tons per sq. in.	Elongation on $4\sqrt{a}$, per cent.	Reduction of area, per cent.	Izod impact value, ft. lb.	Modulus of elasticity, tons per sq. in.
deg. F.	deg. C.							
68	20	62·0	56·0	—	22·0	55	61	13,850
900	482	40·0	33·0	19·9	24·0	69	39	11,500
950	510	41·0	33·0	18·4	23·0	66	40	11,300
1,000	538	35·8	27·8	17·0	27·5	74	33	11,100
1,050	566	33·2	23·4	11·4	31·5	78	37	11,000
1,100	593	31·6	20·7	8·5	36·5	79	37	10,800

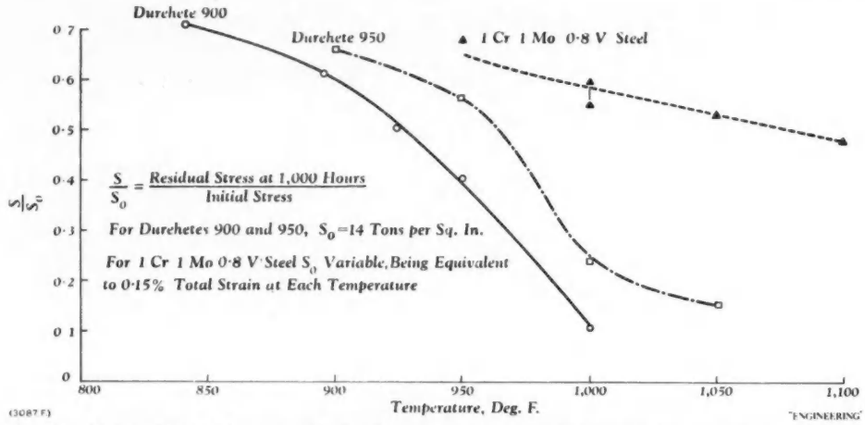


Fig. 6 Comparison of 1 per cent. chromium, 1 per cent. molybdenum, 0·8 per cent. vanadium steel with established materials.

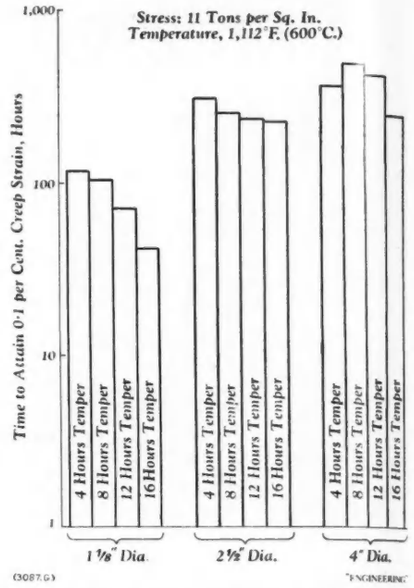


Fig. 7 Effect of tempering and section size on the creep resistance of a 1 per cent. chromium, 1 per cent. molybdenum, 0·8 per cent. vanadium steel (Cast " B ").

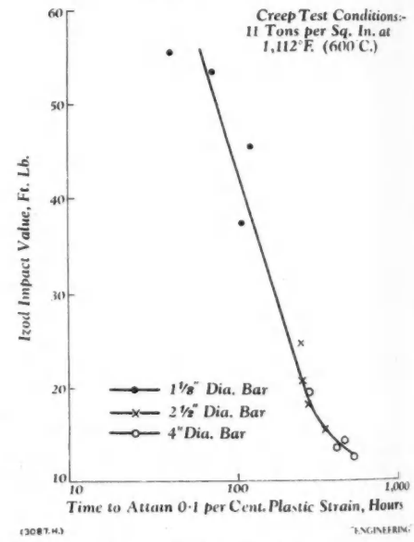


Fig. 8 Relationship between impact and creep strength of the 1 per cent. chromium, 1 per cent. molybdenum, 0·8 per cent. vanadium steel (Cast " B ").

carbide, namely, V_4C_3, but also to the presence of another carbide which, either directly or by slowing down the precipitation of the former, acts to increase the resistance to deformation.

That the presence of V_4C_3 itself does not necessarily confer maximum creep strength is illustrated by the behaviour of the 0·8 per cent. vanadium steels containing between 1·60 and 3·15 per cent. molybdenum. The progressive reduction in creep strength shown by steels having molybdenum contents above 1 per cent. is probably due to the effect this element has upon the dispersion and size of the V_4C_3. The higher molybdenum steels, Nos. 21 to 24, were alone in being coarse grained after solution treatment at 1,050 deg. C., suggesting that molybdenum increases the solubility of vanadium in austenite while at the same time it competes with it for the available carbon on tempering at 700 deg. C. This is evidenced by the presence of molybdenum-bearing Mo_6C carbide in steel No. 24 containing 3·15 per cent. of molybdenum.

The characteristics of the various carbides likely to be found in steels of this type and their possible influence upon high-temperature strength have been outlined by Crafts and Lamont[2*], who pointed out that V_4C_3 with its cubic structure and resistance to growth appeared to be the most desirable in this respect. Colbeck and Rait[3] showed that the rapid decrease in creep properties with increase from 1 per cent. to 8 per cent. Cr was associated with the disappearance of V_4C_3 and the formation of Cr_7C_3. It seems probable from the present work that the size and dispersion of the various carbides is equally as important as the type of carbide in governing the high-temperature strength and that the effect of alloying elements upon creep resistance may often be due to their influence upon this aspect of carbide behaviour.

This discussion has referred to the steels containing 0·2 per cent. carbon; the same general argument can be applied to the four higher carbon steels examined (Nos. 13 to 16), but the six 0·1 per cent. carbon steels, Nos. 1 to 6 inclusive, showed somewhat different behaviour. While they attained the same optimum low deformation creep strength as the 0·2 per cent. and the 0·3 per cent. carbon steels, Fig. 1, their optimum rupture strength lay below that of these steels, Fig. 3. It might be significant in this connection that the strongest of the 0·1 per cent. carbon steels, No. 3, developed Mo_6C and not V_4C_3 upon testing at 600 deg. C.

Arising out of this experimental work it was decided to confine further examination to 0·2 per cent. carbon, 1 per cent. chromium, 1 per cent. molybdenum steels containing between 0·7 and 0·9 per cent. vanadium. The remainder of this article is concerned with properties obtained upon three works casts made to this analysis.

TESTS ON COMMERCIAL MATERIAL

Various tests have been made on three commercial casts of the following percentage analysis :—

Cast No.	C	Mn	Si	Cr	Mo	V
A	0·25	0·41	0·17	1·30	1·02	0·89
B	0·26	0·37	0·16	1·21	1·04	0·84
C	0·21	0·39	0·17	1·32	1·04	0·87

(*a*) *Typical Properties.*—Cast A, in 1⅛ in. diameter bar form, was used to determine mechanical properties up to 1,100 deg. F. (Table VI). resistance to embrittlement at 950 deg., 1,000 deg. 1,050 deg., and 1,100 deg. F. for times up to 3,000 hours (Table VII), and constant strain-relaxation properties at 950 deg., 1,000 deg., 1,050 deg. and 1,100 deg. F. (Table VIII). This cast was oil quenched from 1,050 deg. C. and tempered at 700 deg. C. for nine hours. The general level of properties exhibited in the temperature range 950 to 1,100 deg. F. confirmed its possibilities as a bolt steel to operate at temperatures up to at least 1,050 deg. F. This is emphasised in particular by the comparison made, in Fig. 6, with Durehete 900 and 950 qualities in which the residual stress at 1,000 hours, as a ratio of the initially applied stress, is shown as a function of the test temperature.

(*b*) *The Effect of Section Size upon the Properties.*—The heat treatment given to a bolting material is governed by the need for a specified tensile strength coupled with adequate impact resistance in large sections. As has been mentioned earlier, it is in larger section sizes that many of the high-temperature bolts are required, so that it is important to ensure that both tensile and creep resistance demands can be met at all likely sizes. Accordingly, tests were made on 1⅛ in., 2½ in. and 4 in. diameter bars of cast B after oil-quenching from 1,050 deg. C. and tempering for 4, 8, 12 and 16 hours, respectively, at 700 deg. C. The room temperature mechanical properties got from these treatments showed the anticipated reduction in ultimate-tensile and yield-stress values with

TABLE VII.—*Cast A: 1 Cr 1 Mo, 0·8 V Steel—Resistance to Embrittlement.* 1⅛ inch Diameter Bar.

As heat treated, 61 ft. lb.

Reheating temperature		950	1,000	1,050	1,100
deg. F.		510	538	566	593
Izod impact value (ft. lb.) after reheating for the following times:—					
(Hours)	1,000	58	66	76	67
	2,000	—	65	61	60
	3,000	—	57	72	—

TABLE VIII.—CAST A: 1 Cr, 1 Mo, 0·8V STEEL—STRESS-RELAXATION PROPERTIES

Initial Strain : 0·15 per cent. 1⅛ in. diameter bar.

Test temperature, deg. F.		950		1,000		1,050		1,100	
deg. C.		510		538		566		593	
Initial stress, tons per sq. in.		17·0		14·9		13·25		12·0	
		1st load application	2nd load application	1st load application	2nd load application	1st load application	2nd load application	1st load application	2nd load application
Residual stress, tons per sq. in. at:—									
(hours)	1	15·90	16;35	13·40	13·90	11·80	12·35	10·45	11·00
	10	15·30	15·60	12·20	13·20	10·65	11·55	9·30	10·35
	100	13·95	14·65	10·50	12·20	9·15	10·45	7·95	9·05
	300	13·05	13·95	9·50	11·60	8·30	9·70	7·10	8·15
	1,000	11·60	—	8·30	10·70	7·10	—	5·75	—

* See references on page 827.

increase in tempering time without any effect upon the ductility. The creep strength at 1,112 deg. F. (600 deg. C.) was progressively reduced by increased tempering time in the case of the 1⅛ in. bar, but was affected to a lesser degree in the case of the two larger sizes. These results, shown in histogram form in Fig. 7, are considered to reflect the differing behaviour of tempered martensite (1⅛ in. in diameter) and tempered bainite (2½ in. and 4 in. in diameter) structures; the superior creep strength of bainitic structures in low alloy steels of this type has been known for some years.[3] The 2½ in. and 4 in. diameter material tempered for 16 hours at 700 deg. C. (62·3 and 62·5 tons per square inch tensile strength, respectively) were thus more creep resistant than the 1⅛ in. material tempered for only four hours at 700 deg. C. (70·3 tons per square inch tensile strength). Another aspect of these results is shown in Fig. 8, in which the room temperature impact resistance of each specimen is shown in relation to its creep strength at 1,112 deg. F. (600 deg. C.). This correlation is probably associated with the manner of carbide precipitation from steels having, respectively, martensitic or bainitic matrices.

Since it is considered undesirable to have the relatively low impact values, as obtained by those treatments in the larger section sizes, it has become necessary to adjust the tempering conditions to improve this property. Impact resistance of the order displayed by cast A in 1⅛ in. diameter form can be taken as a desirable level. This is associated, as Fig. 6 indicates, with creep resistance entirely adequate for its use at a service temperature of 1,050 deg. F. but lower than could be got if a lower impact resistance could be tolerated (Fig. 8). Accepting the former criterion demands more severe tempering, and hence lower tensile strength, of the more creep-resistant larger-bainitic sections. This feature is illustrated by the results of tests made on 1 in., 2½ in. and 4 in. diameter bar of cast C. Specimens of each section size were heat treated to around 55 and 65 tons per square inch tensile strength, and their creep strength at 1,112 deg. F. (600 deg. C.) determined. The room-temperature tensile strengths are listed in Table IX and the creep data in Fig. 9. It will be noted that the creep resistance of the 2½ in. and 4 in. bars heat-treated to a tensile strength of 55 tons per square inch corresponds to that of 1 in. bar heat-treated to a tensile strength of 70 tons per square inch, the respective impact values being 61, 59 and 55 ft.-lb.

TABLE IX.—CAST C: 1 Cr, 1 Mo, 0·8 V STEEL—EFFECT OF HEAT TREATMENT UPON TENSILE STRENGTH

Section size	1 in.	2½ in.	4 in.	1 in.	2½ in.	4 in.
Heat treatment	Oil-quenched from 1,050 deg. C.; tempered at 740 deg. C. for 6 hours			Oil-quenched from 1,050 deg. C.; tempered at 740 deg. C. for 1 hour		
Ultimate tensile stress, tons per square inch	54·2	54·1	53·9	69·9	65·0	66·4
Yield stress, tons per sq. in.	47·8	—	—	58·2	—	—
0·2 per cent. proof stress, tons per sq. in.	—	45·3	44·7	—	57·4	59·4
Elongation on $4\sqrt{a}$, per cent.	22·5	22·4	22·0	21·5	20·0	20·8
Reduction of area, per cent.	61	61	61	62	53	58
Izod impact value	70 : 70 : 70	61 : 61 : 61	56 : 58 : 62	55 : 55 : 55	15 : 18 : 25	16 : 14 : 20
Average, ft.-lb.	70	61	59	55	19	17

SUMMARY AND CONCLUSIONS

The purpose of this article has been to outline some recent developments in meeting the increasingly severe requirements for ferritic bolt steels. Mention has been made of the properties of a 1 per cent. Cr, 0·5 per cent. Mo, 0·25 per cent. V steel (Durehete 950) suitable for long-time bolt service at metal temperatures up to 950 deg. F.; the further requirement of a bolt steel for operation at metal temperatures up to 1,050 deg. F. has been examined first by a systematic study of the influence of carbon, molybdenum and vanadium upon the properties of 24 experimental 1 per cent. chromium steels and then by more extensive tests upon three commercial casts of a composition based on this experimental work. This suggested that the type of carbides present in these steels played a very important role in governing the creep strength. The tests made upon the commercial casts clearly showed the 1 per cent. Cr, 1 per cent. Mo, 0·75 per cent. V steel to possess adequate creep resistance for service as a bolt steel at 1,050 deg. F.; the effect of section size upon its properties has been examined and it is concluded that to ensure adequate impact strength the larger section sizes should be tempered to a lower tensile level. This can be accomplished without sacrificing creep strength, relative to that of 1⅛ in. diameter bar.

APPENDIX

The creep resistance of bolting materials is more suitably determined by a stress-relaxation test than by a constant-load creep test, although the latter is useful for initial sorting purposes. The former is basically a creep test which determines the relationship between stress and time when strain and temperature are held constant. As creep strain occurs there is a corresponding decrease in the elastic strain, so that $\frac{S_0}{E} = \frac{S}{E} + X$, where S_0 is the initially applied stress, X the plastic strain at the time when the stress is S, and E the modulus of elasticity at the test temperature. This condition of constant total strain simulates the behaviour in a flange of a turbine casing which is hypothetically completely rigid, or alternatively, one in which the relaxation of the flange assembly is identical with that of the bolt. In practice, the plastic extension of a bolt is usually compensated for by elastic extension of the flange assembly in addition to the elastic contraction of the bolt so that the residual stresses obtained in the laboratory stress-relaxation tests given in this article are lower than would be expected in an actual bolted assembly.

Acknowledgments.—The authors wish to express their thanks to Mr. F. H. Saniter, Director of Research, The United Steel Companies, Limited, for permission to publish this article and to Dr. H. Hughes who carried out the X-ray analyses incorporated in it.

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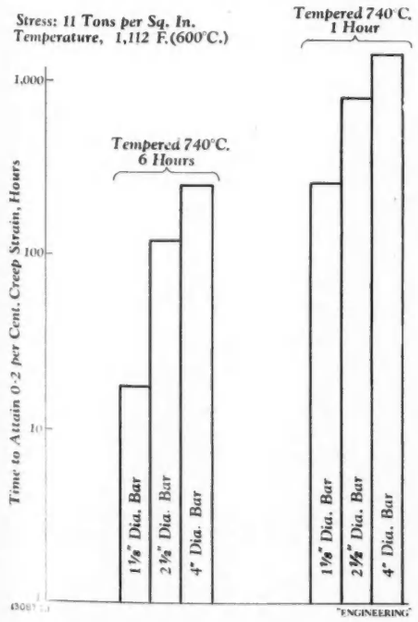

Fig. 9 The effect of tempering and section size on the creep resistance of a 1 per cent. chromium, 1 per cent. molybdenum, 0·8 per cent. vanadium steel (Cast "C").

LORRIES AND TRACTORS

New Assembly Shops for Special-Purpose Vehicles

The opening of new premises at Fleet, Hampshire, enabled County Commercial Cars, Limited, to stage a display of their range of vehicles, including both their tractors and lorries. Of the four companies which form the group, County Commercial Cars, Limited, are primarily concerned with tractors; Walkers and County Cars, Limited, with lorries; and Market Transport, Limited, with vehicles for the transport of meat and general foodstuffs.

On show among the tractors (which utilise the Fordson Major engine as the power unit) was the "Fourdrive," a wheeled vehicle with a top speed of over 12 m.p.h. Chain drives connect front and rear wheels and steering is effected by clutch and brake as for a track vehicle. The "Fourdrive" has been developed for use in sugar cane plantations, where it has proved more suitable than a tracked machine over the rough ground and cane stalks. Also on show were the Dinkum Digger, a side-boom crane, and tractors provided with extended treads for soft soils.

Four examples of the "Jekta" telescopic bodies were shown in the lorry section. These ranged from 4 to 25 cub. yd. capacity and included the Paladin refuse vehicle for operation with large storage bins. The Market Loader was shown both fitted to covered vehicles for meat transport and as an industrial version—the Ganty Loader—on a flat lorry. The loader consists of a tubular frame, from the top section of which the load is hung and pivoted at the floor level of the vehicle; it is raised and lowered hydraulically. In the meat vehicles the hooks are mounted on rollers, and the mounting on the gantry forms a continuous run with rails on the roof of the vehicle when the gantry is raised. Thus the loaded hooks can be pushed into the vehicle body, using a pole, without any risk of the meat touching the floor, or any need for someone to enter the vehicle. The gantry in the industrial version is mounted on a carriage on each side of the vehicle and can be moved along the body.

The new premises consist of a block of offices facing the road and behind them an assembly shop. The latter has two 60 ft. bays and is 200 ft. long. Above each bay is an overhead crane. The structural steelwork is painted a light blue and the walls to the roof line are white; against these the cranes are painted red, making them clearly visible. An extension is being built on the west side of the assembly shop to house a canteen and a drawing office on the first floor, and a paint shop on the ground floor. Heating is by two oil-fired boilers, the oil storage being conveniently located below a loading ramp, and fan distributors which are suspended from the trusses. The architect for the building work was Mr. John N. Coleman, L.R.I.B.A.

CASTIGLIANO'S "THEOREM OF COMPATIBILITY"

ANALYSIS OF NON-LINEAR STRUCTURES

By Professor J. A. L. Matheson, M.B.E.*

In many discussions of Castigliano's Theorem of Least Work, of which perhaps the most recent is that by Brown,[1] the point is made that the theorem applies only to initially unstressed linear elastic structures. While this is generally true, an exceptional case of some interest occurs when the changes of length e of the bars of a pin-jointed framework are connected with the forces F in them by the relationship

$$e = a\,F^n \quad . \quad . \quad . \quad (1)$$

Engesser[2] pointed out that, in this case, the application of the equation of Least Work,

$$\frac{\partial U}{\partial X_i} = 0 \quad . \quad . \quad . \quad (2)$$

where U is the strain energy and X_i a redundant quantity, gave the same result as the method of Virtual Work which is valid for structures having any load-deflection law, linear or otherwise. As he gave no formal proof of this rather surprising fact, the following explanation will be of interest.

The proof of Castigliano's Theorem of the Differential Coefficients of the Internal Work, Part 2†, is well-known and need not be repeated here. The theorem states that, if the strain energy U of a structure is expressed as a function of the applied loads, then

$$\frac{\partial U}{\partial P_j} = \Delta_j \quad (3)$$

where P_j is one of the applied loads and Δ_j is the "corresponding" deflection. Equation (3) is valid only for linear structures; if the strain energy of a structure obeying the load-deflection law of equation (1) is differentiated* with regard to one of the applied loads, then it can readily be demonstrated that the result is given by

$$\frac{\partial U}{\partial P_j} = n\,\Delta_j \quad . \quad . \quad . \quad (3a)$$

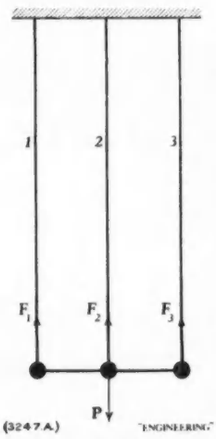

Fig. 1 In this simple hyperstatic framework the middle bar is redundant. The cross-bar is rigid.

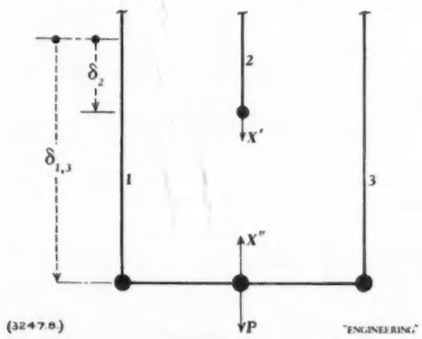

Fig. 2 The redundant bar 2 has been cut and forces X′ and X″ applied so as to draw the cut faces towards each other. Deflections are measured downwards from the level of the cross-bar before P was applied.

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† The rather cumbersome title originally bestowed by Castigliano himself is used here to avoid ambiguity; Southwell[3] describes it as the "First Theorem of Castigliano," while Brown[1] refers to it as "Castigliano's Theorem for Linear Structures." In the remainder of this article it is referred to as "Castigliano's Theorem, Part 2."

The application of Castigliano's Theorem, Part 2, to hyperstatic, or statically indeterminate, structures leads at once to his Theorem of Least Work. In such structures there are more bar forces than can be found from the equilibrium equations alone and additional equations—equal in number to the number of redundant bars—must be obtained from considerations of compatibility of displacement. For example, in the simple structure of Fig. 1, we know from symmetry that if bars 1 and 3 are identical

$$F_1 = F_3 \quad . \quad . \quad . \quad (4)$$

and from considerations of equilibrium that

$$F_1 + F_2 + F_3 = P. \quad . \quad . \quad (5)$$

The remaining equation, which must express the fact that all the bars extend by the same amount, can conveniently be obtained by means of equation (3) as follows. Suppose that a cut has been made close to the end of the redundant bar 2, as in Fig. 2, and that variable external forces X′ and X″ have been applied to the cut faces so as to draw them together. The downward deflection of the bars 1 and 3 will be $\delta_{1,3}$ and that of the bar 2, will be δ_2. We then have

$$\delta_{1,3} = -\left[\frac{\partial U}{\partial X''}\right]_{1,3}$$

and

$$\delta_2 = +\left[\frac{\partial U}{\partial X'}\right]_2 \quad . \quad . \quad (6)$$

The negative sign in the first of these arises because $\delta_{1,3}$ is opposite in direction to X″.

The physical requirements of the problem can now be satisfied by making suitable adjustments to the forces X′ and X″, and the first step is to express the fact that the two quantities are equal by writing

$$X' = X'' = X.$$

Compatibility of displacement is achieved when the forces X are large enough to close the imaginary gap, and so we can write

$$\delta_{1,3} = \delta_2$$

i.e.,

$$+\left[\frac{\partial U}{\partial X}\right]_{1,3} + \left[\frac{\partial U}{\partial X}\right]_2 = 0$$

i.e.,

$$\left[\frac{\partial U}{\partial X}\right]_{1,2,3} = 0 \quad . \quad (7)$$

* In such cases the correct deflection is given only if complementary energy is used rather than strain energy.

Equation (7) is, of course, equation (2) applied to the three bars of this particular structure. The value of X which it yields is equal to F_2, the force in the redundant bar.

If the extensions of the bars had been governed by the relationship (1), then (6) would have been given by (3a) instead of by (3) and we should have had

$$\delta_{1,3} = -\frac{1}{n}\left[\frac{\partial U}{\partial X''}\right]_{1,3}$$

and

$$\delta_2 = +\frac{1}{n}\left[\frac{\partial U}{\partial X'}\right]_2 \quad . \quad . \quad (6a)$$

When the exponent n is the same for all the bars, the final step yields equation (7) as before, unless the frame is self-strained.

This reasoning can be extended to more elaborate frames with several redundancies; we therefore conclude that equation (2) can be applied to hyperstatic structures which are initially unstressed and whose members obey the deflection law (1). When applied to the component parts of such structures, Castigliano's Theorem, Part 2, gives deflections which are a simple multiple of the correct values and are therefore in the correct ratio.

The importance of all this is that it directs attention to the real significance of the so-called Equation of Least Work. For if the redundant bar 2 is initially an amount λ too short, so that it has to be forced into position when the frame is assembled in the first instance, the equation of compatibility will be

$$\delta_2 - \delta_{1,3} = \lambda$$

i.e.,

$$\left[\frac{\partial U}{\partial X}\right]_{1,2,3} = \lambda \quad . \quad . \quad (7a)$$

as can be seen from a consideration of the diagram, Fig. 3, below.

The Equation of Least Work, equation (2), is now seen to be a special case of the Equation of Compatibility, and

$$\frac{\partial U}{\partial X_i} = \lambda_i \quad . \quad . \quad . \quad (8)$$

It is only when there is no self-straining and $\lambda = 0$ that equation (2) is correct and it is only in such cases as these that the strain energy is a minimum.

Unfortunately the familiar title "Least Work" emphasises what is now seen to be an incidental property of the strain energy which occurs only in the special case. It would be much better to use the title "Castigliano's Theorem of Compatibility" for this method; in this way we should acknowledge the authorship, correctly describe the fundamental idea, and avoid confusion with the quite distinct Principle of Minimum Potential Energy.

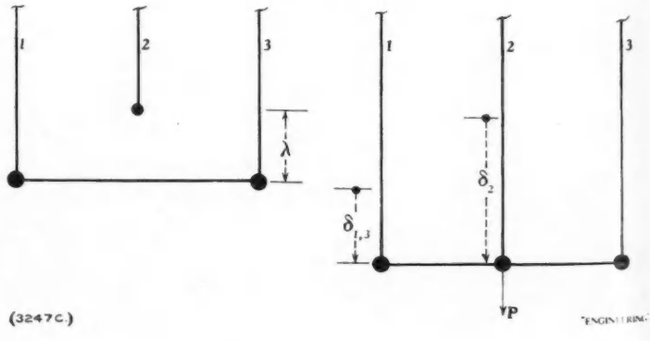

Fig. 3 If the redundant bar is λ too short it will have to be forced into place. The deflections used in the equation of compatibility now differ by λ.

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The Iron and Steel Institute Autumn Meeting in London (*continued from page* 798)

SLAG REQUIREMENTS IN STEELMAKING

EFFECT OF SULPHUR IN FURNACE OIL

Continuing our report of the annual autumn general meeting of the Iron and Steel Institute, held in London on November 16 and 17, we give below an abstract of the second paper presented on the morning of the first day, together with an outline of the discussion to which it gave rise. The proceedings at the afternoon session of Wednesday, November 16, are also summarised.

"The Relative Merits of Low and High-Sulphur Oil for Open-Hearth Steelmaking" was the title of the paper. It was by Dr. C. A. Edwards, F.R.S., formerly Professor of Metallurgy at University College, Swansea, who noted that from an extensive series of test charges when using 50 per cent. hot metal and 50 per cent. scrap it had been found that the sulphur pick-up from the furnace gases was as shown in Table I.

TABLE I.

Sulphur in liquid fuel.	Sulphur pick-up per 100 tons of steel.
Per cent.	Lb.
1·0	25
1·3	40
1·7	60
2·3	90

The results indicated that for the production of 100 tons of steel containing 0·025 per cent. of sulphur, about 11·6 extra tons of slag were required if the fuel contained 2·3 per cent. of sulphur than if the fuel contained only 1·0 per cent. of sulphur.

In general terms it could be said that whatever the sulphur specification of the steel might be, substantially less tapping slag was required when a low compared with a high-sulphur oil could be used, provided that the phosphorus load of the charge could be kept below certain limits.

DISCUSSION

In opening the discussion, Dr. J. Pearson said that Dr. Edwards had obviously been concerned, in common with many metallurgists, by the serious difficulties that high sulphur caused in open-hearth operation, and, very laudably, he had attempted to give these a quantitative basis. By subtracting from the total burden at tapping the sulphur in the materials charged, he had arrived at a series of figures for sulphur pick-up, given in Table I (above). Dr. Edwards had shown that when hot metal, high in sulphur, was added to a furnace, it did not lose sulphur because it was under slag cover, and one could assume from this that any metal which was under slag would neither lose nor gain sulphur. It might be assumed, as practical experience indicated, that there was no significant sulphur pick-up by metal of this nature after the melt-down. The sulphur pick-ups which Dr. Edwards had given therefore could be taken as occurring during the melt-down, and that was precisely what the French investigators, MM. B. Trentini, A. Peters and G. Husson, had stated in a paper before the Société Française de Métallurgie in October, 1954. These authors had shown that during the melting down of a charge, some 28 per cent. of the sulphur contained in the oil fed to the furnace was actually absorbed by the charge. In a similar experiment carried out by the B.I.S.R.A. staff at Sheffield on a furnace which had about 50 per cent. hot metal in the charge, this had also picked up during the melt-down a similar amount of sulphur from the oil. Consequently, it could be said that the sulphur pick-up appeared to be directly dependent on the sulphur content of the oil only if the amount of oil used during melting down were constant.

Dr. Edwards tended to dismiss too lightly the published work on sulphur distribution and had come to the conclusion that there was no simple relationship between slag basicity and the sulphur-distribution ratio. That was no news to people interested who had read the research work on the subject, nor to steelmakers, who all stated that the degree of oxidation was also a very important factor in sulphur distribution. What Dr. Edwards had done was to show that there was a good relationship between sulphur distribution and the basicity versus the residual manganese content. That might be a very important and useful relationship for works operation, and it might indicate a lot of things that could be done. This, in itself, however, was merely a presentation of already known knowledge in a new form.

Dr. C. A. Edwards, in reply, said that there was no intention in the paper to suggest that manganese acted in any mysterious way. He felt that it was merely a reflection of the oxygen content of the metal, and was just another way of showing how it was possible to get a clear picture of the whole situation by reference to the manganese content of the bath at tapping.

Mr. J. W. Till said that steelmakers would be grateful to Dr. Edwards for his data, particularly those who had to make low-sulphur steel from high-sulphur fuels. They at the Shotton Works of John Summers and Sons, Limited, were pleased to find that Dr. Edwards' work confirmed quite a number of their findings, which had been published originally under the late F. L. Robertson's name in the *Transactions* of the American Institution of Mining & Metallurgical Engineers in November, 1951. Those results, at that time, covered about 400 casts and were on an 80 ton cold-metal charge with one type of fuel containing 2·5 per cent. of sulphur. Dr. Edwards' work on differing sulphur fuels fitted in with their figures, including some values obtained later in their new shop with hot metal and mixed-fuel firing.

With regard to the amount of sulphur pick-up in lb. per 100 tons, they had not many casts available in their hot-metal practice, but those that they had were based on 65 per cent. hot metal, and they gave figures very near to those quoted by Dr. Edwards. For 1 per cent. sulphur-content tar and coke-oven gas they had a pick-up of 26 lb. as compared with Dr. Edwards' 25 lb., and for 2·5 per cent. oil and coke-oven gas they had 78 lb. compared with his 90 lb. This was understandable, their coke-oven gas probably being of lower sulphur content than the other fuels, and therefore the average sulphur of the gaseous fuel in the furnace was probably nearer 2 per cent. rather than 2·5 per cent.

Dr. B. Trentini said that, in France, there were also difficulties in obtaining low-sulphur oil for open-hearth furnaces. Some differences existed between Dr. Edwards' work and that carried out for the Institut de Recherche de la Sidérurgie (IRSID) but the general conclusions were similar. In Dr. Edwards' work, the charges contained 50 per cent. hot metal. In their case the tests had been carried out in a non-integrated, plant, so they had had to use cold charges. The proportion of solid pig iron, however, was only 15 per cent. The sulphur content of the fuel varied over wider limits, from 0·4 to 5·8 per cent. They had tried to maintain the operating factors as constant as possible, in particular the nature and apparent density of the scrap, and the amount of lime charged.

The definition of slag basicity was a difficult problem as could be seen from the numerous formulae proposed by many authors, and the oxidising power of a slag was not always known accurately; these two reasons might explain the scatter of points often obtained in de-sulphurisation studies.

CARBON AND NITROGEN IN IRON ALLOYS

The whole of the afternoon of Wednesday, November 16, was devoted to the presentation and joint discussion of seven papers, the first four dealing with various aspects of the "Thermodynamics of Carbon Dissolved in Iron Alloys and the last three with the "Solubility of Nitrogen in Alpha-Iron." With the exception of the fifth paper, which was by Mr. J. D. Fast and Mr. M. B. Verrijp, who belong to the Philips Research Laboratories, Eindhoven, Netherlands, all the papers were communications from the Chemistry Department of the British Iron and Steel Research Association.

All the papers were presented by Dr. E. T. Turkdogan, head of the physical-chemistry section of the Chemistry Department of the Association.

The first paper, Part I of the "Thermodynamics of Carbon," series, dealt with the solubility of carbon in iron-phosphorus, iron-silicon, and iron-manganese melts, and was by Dr. Turkdogan and Mr. L. E. Leake. The authors stated that they had determined the solubilities of carbon in iron-phosphorus melts at 1,290 deg., 1,490 deg., and 1,575 deg. C. Phosphorus, like silicon, decreased the solubility of carbon in iron. Manganese, on the other hand, increased the solubility of carbon in iron.

Part II, on the influence of silicon on the activity coefficient of carbon dissolved in molten iron, was by Dr. Turkdogan. He observed that the activity coefficient of carbon in iron-silicon-carbon melts had been calculated by an empirical method. The investigation had shown that the effect of silicon on the activity coefficient of carbon was a function of carbon concentration and independent of temperature.

Part III dealt with the solubility of carbon in iron-sulphur melts and was by Dr. Turkdogan and Mr. R. A. Hancock. They stated that they had determined the solubility of carbon in iron-sulphur melts at 1,200 deg., 1,350 deg., and 1,500 deg. C. It had been found that dissolved sulphur decreased the solubility of carbon to a greater extent than did silicon and phosphorus. The miscibility gap in the iron-sulphur-carbon system had been determined by several metallurgists. In the present investigation the sulphur content of the carbon-saturated miscibility boundary had been found to increase only slightly with rise of temperature, namely, from 1·82 per cent. at 1,200 deg. C., to 1·92 per cent. at 1,500 deg. C. This increase was much less than that found by previous workers.

The fourth and final section in the series of papers on the thermodynamics of carbon dissolved in iron alloys, was on the subject of solubility of carbon in Fe-Si-P melts, and was by Dr. Turkdogan and Mr. Leake. They stated that they had determined the joint effect of silicon and phosphorus on the solubility of graphite in molten iron at 1,290 deg. and 1,490 deg. C. Because dissolved phosphorus and silicon lowered the solubility of graphite in iron, the presence of these two alloying elements together should reduce the carbon solubility to a much greater extent. The results had shown, however, that the individual effects of phosphorus and silicon on the solubility of graphite in iron were not additive. One of the causes of this might be the stronger interaction of silicon with the iron-phosphorus system than that with iron alone.

The first of the three papers on the solubility of nitrogen in iron was that by Mr. J. D. Fast and Mr. M. B. Verrijp. They stated that the internal friction of fine-grained textureless α-iron wires caused by nitrogen had been found to be proportional to the nitrogen content up to a concentration corresponding to the solubility at the eutectoid temperature (0·095 wt. per cent. at 585 deg. C.). Making use of this fact, the

solubilities of nitrogen in α-iron in equilibrium with Fe_3N, Fe_4N, and N_2 of 1 atmosphere, respectively, had been measured.

The second paper in the nitrogen-solubility series was entitled " The Solubility of Nitrogen in Pure Iron and in 2·83 per cent. Silicon Iron " and was by Dr. N. S. Corney and Dr. Turkdogan. They stated that the nitrogen solubility in α-iron at 502 deg. C., in equilibrium with iron nitride, had been found to be 0·060 per cent., and at 605 deg. C., in α-iron in equlibrium with $(\alpha + \gamma)$ iron, to be 0·100 per cent. nitrogen. It had been found that dissolved silicon (2·83 per cent.) reduced the solubility of nitrogen in α-iron, for example, from 0·0033 per cent. to 0·0019 per cent. at 900 deg. C., under 1 atmosphere of nitrogen.

The last paper presented on Wednesday afternoon dealt with the solubility of nitrogen in α-iron containing up to 0·051 per cent. of vanadium. It was by Dr. Turkdogan, Mr. S. Ignatowicz and Dr. J. Pearson. They stated that the solubility of nitrogen in α-iron, containing 0·016 per cent. and 0·051 per cent. of vanadium, had been investigated by bringing the alloys into equilibrium with ammonia-hydrogen mixtures at 500 deg. and 600 deg. C. The results had indicated that, up to a quantity of 0·051 per cent., vanadium had no influence on the solubility of nitrogen in α-iron. There were no indications of the formation of a vanadium nitride phase at nitrogen potentials below those of iron nitride, Fe_4N. This threw doubt on the assumption that the stabilisation of steels against strain ageing by vanadium was due to nitride formation.

The presence of carbon, oxygen and sulphur in mild steel, however, should not be overlooked. It was possible that an element such as vanadium might tend to form complex compounds. The behaviour of vanadium in mild steel might not be directly comparable with its effects in pure iron.

DISCUSSION

Dr. F. D. Richardson, in opening the discussion, said that the measurements conducted by the authors had obviously been most thoroughly carried out and, quite clearly, would stand for a considerable time. At low concentrations of sulphur, silicon and phosphorus it had been shown that phosphorus, sulphur and silicon all had very similar effects in suppressing the solubility of carbon, gramme atom for gramme atom. At higher concentrations, sulphur had more effect than phosphorus, which had more effect than silicon. Phosphorus and silicon together had effects which were roughly additive.

A subsequent speaker, Mr. J. R. Brown, commenting on Dr. Turkdogan's paper on the solubility of nitrogen in α-iron and silicon-iron, said that the aluminium content of his sample was 0·0003 per cent. This, if aluminium nitride were formed, should account for about 0·0015 per cent. of nitrogen. This was a very small amount of nitrogen but quite appreciable in respect of the rest of his measurements. He wondered if he could have any information on whether aluminium nitride was formed.

To be continued

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ST. ALBANS BY-PASS

Alignment of 16 Mile Motorway

Details of the proposed route of the St. Albans by-pass, 16 miles long and expected to cost £5½ million, have been published by the Minister of Transport. It will link London's north orbital road and the Watford by-pass with the proposed London-Yorkshire motorway and the A.6 near Luton. (Details of the London-Yorkshire motorway were given in ENGINEERING, for September 30 last on page 443). The new road is to run roughly north-south with an inverted Y at the southern end; it will have dual carriageways, each 36 ft. wide, for the greater part of its length and where possible flyover connections, though roundabouts will be constructed at the southern extremities.

RAILWAY RECONSTRUCTION AT POTTERS BAR

NEW STATION AND IMPROVED SIGNALLING

The new station, which has recently been completed at Potters Bar on the main line of the Eastern Region, British Railways, from London to Scotland, marks the first stage in the removal of a " bottleneck " on this important traffic route. Hitherto there has only been one down and one up line from Greenwood signal box, 10 miles from London, to beyond Potters Bar station and this section, of 2½ miles, includes three tunnels of a total length of 1,830 yd. Two additional tracks have now been laid from the north portal of Potters Bar tunnel through the station, about ½ mile away (where two new island platforms have been provided) to connect with the existing quadruple tracks northward. In addition to the new station buildings and other offices, a much enlarged goods yard and other facilities, it was also necessary to construct one double-span and two single-span bridges over Darkes Lane, the roadway of which has been lowered to give a head room of 16 ft. 6 in. The colour light signals and points, which control the tracks through the station and for some distance in either direction, are operated on the route-setting principle from a new signal box.

Work has also been started on the widening of the line southward through the tunnels to Greenwood and when this has been completed at least four tracks will be available from London to the south approach to Welwyn viaduct, a distance of 22 miles.

The civil engineering work required for this extension has included the provision of retaining walls to the embankments on each side of the line south of the station. These walls consist of pre-cast concrete piles 15 in. by 7½ in. by 18 ft. long which have been driven 10 ft. below the new formation and are V-interlocked. The distribution of prestress in each pile is not uniform across the section in order to accommodate the bending moments set-up by the cantilever construction and at the same time to keep the working stresses within reasonable limits. This work was carried out to the requirements of Mr. A. K. Terris, chief civil engineer, Eastern Region, British Railways, the principal contractors being M. J. Gleeson (Contractors). Limited, North Cheam, Surrey.

NEW BRIDGES

The bridges carrying the main and slow lines over Darkes Lane were fabricated and erected by the Butterley Bridge and Engineering Company, Limited, Butterley, near Derby. They are constructed of fabricated welded plates, have a span of 60 ft. and with stiffeners on the inside faces only, leaving an unbroken face externally. The decks are carried on cross bearers which are seated on special brackets. These brackets are fixed to the bottom of the girder webs and are fitted on mat reinforcement, waterproofed and tiled. The girders are mounted on grillages which are fixed to the tops of the abutments, the free ends being mounted on phosphor-bronze blocks. The abutments are of concrete, 10 ft. thick, and are faced with blue engineering bricks. A view of one of these bridges is given in Fig. 2, opposite.

STATION BUILDINGS

There are two awnings, each 130 ft. long and about 35 ft. wide, over each island platform of the new station. These consist of pre-stressed cantilever slabs, which are connected to two longitudinal cantilever beams to form an inverted T. The two beams in each unit are supported by four columns. The slabs are about 4 in. thick and contain prestressing cables, which are arranged transversely to the main direction of the platform. The beams are of balanced design: that is, under normal dead-weight the loads inside and outside the columns are balanced. The pre-stressing cables are on the upper side of the beams, so that the entire roof is concave at the upper surface under dead load. At maximum loading this curvature will be somewhat reduced. Fig. 1, below, shows one of the main lines and illustrates the construction methods that have been employed.

There is the usual passenger and staff accommodation on each platform. This consists of buildings of unpierced brick panels linked by braced light steel angles. These angles are supported on tubular columns behind the windows and the roofs are of timber. Access to the platforms is given by ramps from a subway in which the booking office is situated. This subway can be approached either from a pedestrian way or from a covered main entrance. The main station building is linked to the goods office and yard by a wall, both being of reinforced concrete construction.

The general contractors for the station, platform buildings and goods offices, as well as

Fig. 1 The main-line platforms at the new Potters Bar station, British Railways, Eastern Region, as seen from the down side, showing the roof construction.

Fig. 2 One of the bridges over Darkes Lane, built to accommodate the widening. The bridges are all-welded with stiffeners on the inside of the plate girders only.

for the new signal box, described below, were Kirk and Kirk, Limited, Atlas Works, Putney, London, S.W.15.

SIGNALLING EQUIPMENT

As the old mechanical signal box would have fouled the new island platform on the down-side of the station, a new power-operated signal box and colour lighting signalling equipment has been built at the north end of the station, east of the up slow line. This box is a single storey building in which the relay room and stand-by plant are accommodated, and the operating cabin is situated in an annexe above the north end. The area controlled extends from Potters Bar tunnel to the north, to the station area, where there are connections to the goods yard, lay-by and reversing sidings and a number of facing cross overs between the main and slow lines to give flexibility in operation.

This installation is controlled by route-setting relay equipment, which was designed to meet the requirements of Mr. A. Moss, signal engineer, Eastern Region and the chief operating superintendent by Metrppolitan-Vickers-GRS Limited, 132 Long Acre, London, W.C.2. Its special features are the provision of a central operating position from which a seated signalman can move the route switches without stretching and from which the state of the controlled area and its approaches can be observed on an illuminated diagram, which is illustrated in the accompanying Fig. 3. The geographical system of selecting a route is employed so that the signalman need not memorise the position of the appropriate switches. These requirements have been met by installing a detached console with a central operating position and two wings.

The central operating position consists of a Wareite panel upon which a small replica of the signalling layout system has been processed and upon which the route switches are mounted geographically. To ensure compactness the exit buttons are incorporated in the centre of the twin switch of the next signal ahead. The only lamp indications are located at the end of each individual route. These are illuminated when the signalman has set up the route and the appropriate relay has operated. Indications from the selective type telephones on the signal posts and other communication facilities are located on one wing of the console, while the other is used as a desk.

POINT SWITCHES

Three-position switches are mounted on a vertical panel in front of the consol and are used for moving the individual points to either the normal or reverse position in case of emergency. Lamps installed in the centre of these switches show whether the points are actually moving or are in a position different from that required to set the route. Other lamps below the switches show when the points, which the latter control, are locked. Until this indication has been given the signal for the route will not clear. These lights persist until the route switch has been restored and all the track circuits controlling the points are clear. Other switches on this vertical panel control emergency denotator placers, enable the panel and signal dimming lights to be operated and open the circuit of the " power off " warning bell.

Three-position rotary commutators, which are also installed on the panel, enable block working to be continued on the down slow line as far as Marshmoor and to be employed on the other three lines when Marshmoor signal box is switched out. These commutators are provided with luminous indicators to show the track conditions. Other luminous indicators inform the signalman to which line the incoming bell signals relate. " Welwyn " control with a time element feature has been incorporated as necessary.

ILLUMINATED DIAGRAMS

A large illuminated diagram is fixed behind the console, enabling all the track circuits and the signal and point indications to be read by the signalman from his central position. A total of 52 routes are controlled from the panel and the installation comprises 40 alternating current track circuits, 16 three-four aspect colour light signals, 15 position light shunt signals, six junction indicator signals, one searchlight signal, one two-aspect signals, four emergency detonator placers and 29 point machines.

The running signals are of the four-aspect multi-lens type with junction indicators at the facing cross-overs. The ground shunt signals are of the positive light type with red-beside-white lights to indicate " stop " and two white lights inching upward to the left to show " off." The running signals are provided with 24 watt 12 volt double filament lamps. One of the filaments is operated at the full wattage, while the other is under-run to give a total loading of 33 watts. The single filament lamps in the ground shunt signals are 25 watt, 110 volts, and those in the junction indicators, 12 watt, 12 volts. There are 14 double-ended sets and one single-ended set of electrically-operated points. A separate motor, which is supplied with direct-current at 110 volts from a battery in the signal box, is provided for each end.

All the relays on the installation, both indoor and outdoor, are of the plug-in type. Those in the relay room are mounted on two long racks, which also carry the point contactors, fuses and bus bars. All this equipment, as well as the illuminated diagram and console, were wired before delivery. Rubber-covered multicore cables with a rubber compound sheath are used on the signal control circuits. These are usually buried, but are sometimes in surface troughing.

A supply of power is derived from the mains at 415 volts three-phase and is stepped up to 650 volts single phase for distribution. In case of failure of this supply, a 30 kVA Diesel engine-driven generator takes over the load.

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ALL-WELDED ALUMINIUM RAILWAY WAGONS

Eliminating Painting for Protection

All-welded aluminium hopper wagons, 28 in number and each of 2,000 cub. ft. capacity, recently went into bauxite-carrying service with the Roberval and Saguenay Railway, Canada. The first of their kind, these new wagons join a fleet of 90 aluminium wagons of more orthodox construction already in service. They have a tare weight of 18 tons and a load capacity of 87 tons. The wagons were made by the Canadian Car and Foundry Company, and most of the welding was carried out using equipment normally employed for steel wagons.

In drawing attention to these wagons, the Northern Aluminium Company, Limited, Banbury, noted earlier, successful, uses of aluminium-bodied hopper wagons operated in the North American continent. In particular, ten 70 ton wagons have been used since 1931 for carrying bauxite, sulphur and coal for the Aluminium Ore Company; each has travelled about half-a-million miles and, it is claimed, no major repairs have been required that could be attributed to corrosion. Nearer home, in the United Kingdom, the Cambrian Wagon and Engineering Company, Limited, Cardiff, built a 21 ton aluminium-plated mineral wagon which was put into normal coal-carrying service in 1945 and is still in good condition. In nearly ten years, working in conditions recognised to be extremely severe, no paint has had to be used for protection.

Fig. 3 Interior of the signal box, showing the control panel, telephone board and illuminated diagram.

Fig. 1 Low-cost general purpose tractor. David Brown Tractors (Engineering) Ltd.

FARM MACHINERY

WIDE VARIETY OF EQUIPMENT AT SMITHFIELD SHOW

Among all the varied agricultural implements on show at Earl's Court, London, there was a notable absence—not one was specifically designed for use with a horse. What a difference from the exhibition held by the Smithfield Club in 1798, and from the shows of even more recent years. The tractor has become the maid-of-all-work on the farm, not only as a draught machine, but also as a mobile source of power. Over 20 firms were exhibiting agricultural tractors —3-wheeled, 4-wheeled, half-track or crawlers— and for each there was a wide range of attachments. In addition there were many small horticultural tractors for the allotment or small-holding. The exhibition was open from December 5 to 9.

Perhaps the largest machine on show was the Claas self-propelled combine harvester, driven by a Perkins L4 Diesel engine. This has a 10 ft. cutter bar and the driver sits some 8 ft. above the ground. Several other combines were also being exhibited by British firms both self-propelled and trailer types. Harvesters for potatoes, beet, and hops were on display, some of them improved versions of earlier machines and some for the first time. In fact it would probably be true to say that there was a machine available for every field process on a farm, whether ploughing, sowing, manuring or reaping. Dairy equipment is generally required indoors, but there was at least one portable milking machine that could be carried (in one hand) from cow to cow.

For what might be called the "auxiliary" farming operations, such as fencing, hedging, ditching, draining and the like, machines were also prominent—some independent but the majority for attachment to the ever-useful tractor. Six firms were showing equipment for electrified fences, which seem to be coming very rapidly into wide use. Electricity appears to be becoming as usual indoors on the farm as the tractor is outdoors, and not only for power purposes but also for heating and special-purpose lighting. In fact, the Smithfield Show and Agricultural Machinery Exhibition, to give it its full title (it is organised by a joint committee from the Smithfield Club, the Agricultural Engineers Association and the Society of Motor Manufacturers and Traders) is a true reflection of the enormous strides in mechanisation that have taken place during the post-war years. In this article, a very few of the exhibits are briefly described.

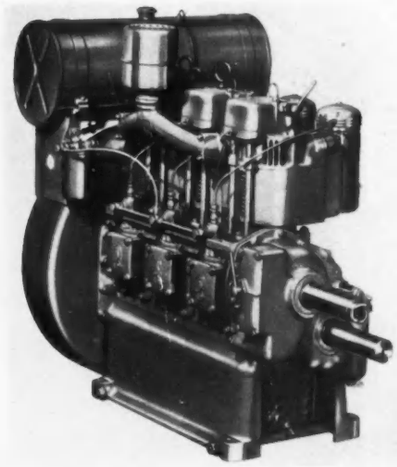

Fig. 2 Three-cylinder air-cooled Diesel engine. Armstrong-Siddeley Motors Ltd.

TRACTOR FOR THE SMALLER FARM

The main exhibit of David Brown Tractors (Engineering), Limited, Meltham, Huddersfield, was a small low-cost tractor with a special appeal for the smaller farm. As may be seen from the illustration, Fig. 1, it has been reduced to essentials.

The power unit is a two-cylinder air-cooled Diesel engine of 3½ in. bore and 4 in. stroke. This develops 12 b.h.p. at 1,500 r.p.m. and is mounted behind the rear wheels. The crankcase is light alloy and the cylinders cast iron with detachable light-alloy heads. Copper-lead bearings are used both in the mains and big-ends. The drive is taken through a foot-controlled dry plate Borg and Beck clutch to a gearbox which gives four forward speeds and a reverse using a sliding gear shift. With the engine running at 1,500 r.p.m. the road speeds range from 1·65 m.p.h. to 7·68 m.p.h. and 2·48 m.p.h. in reverse. The back axle is driven through a spiral bevel gear and the outer ends of the half shafts are internally geared with the wheel hubs. Filters are fitted in both the fuel and the pressure lubrication system. Manoeuvrability is greatly increased by the fact that the rear wheels can be braked separately or together.

Tools and implements are carried between the front and rear wheels by a dual linkage mounted on the front axle. Vertical pillars clamped to the axle beam on each side of the tractor centre line, carry the swivel hitch points. The clamping allows for swivel and sliding adjustment to vary both level and width. On each side are top and bottom links which carry the permanent implement headstocks, the length of the top link being adjustable for pitch. Twin hand levers on quadrants adjacent to the steering wheel raise and lower the linkages, either independently or together by means of a servo-controlled air-lift mechanism, for which the main frame forms the reservoir.

Both front and rear wheels can be adjusted for track widths varying between 40 and 68 in. by 4 in. increments. Adjustment of the front wheels is obtained by detaching the brackets from the axle beam and rebolting in the desired position; and of the rear wheels by using offset wheel rims and reversible dished wheel centres. Both rims and centres are held by four bolts only.

A six-splined power take-off shaft projects forward into the implement space and rotates in a clockwise direction when viewed from the front. It has a fixed speed relation to the rear wheels and revolves at 643 r.p.m. when the engine is running at 1,500 r.p.m. in second gear. The implements available include a single-furrow plough, cultivator, hoe, potato lifter, mowing machine, beet lifter and a trailer. The tractor has a maximum drawbar pull of 1,200 lb. and mark removers are fitted behind the rear wheels. The weight is approximately 2,000 lb.

AIR-COOLED DIESEL

An addition to the range of air-cooled Diesel engines made by Armstrong-Siddeley Motors, Limited, Coventry, is a three-cylinder model exhibited for the first time at this year's show. Single- and twin-cylinder engines in the series have given a power range from 6 to 22 h.p. and the three-cylinder version extends this to 33. It is shown in Fig. 2.

Bore and stroke are both 4·25 in. and the output ranges from 20 h.p. at 1,000 r.p.m. to 33 at 1,800 r.p.m., running on the four-stroke cycle. A vaned flywheel directs cooling air around the cylinders to maintain the correct working temperature. Crank case, cylinder block and head are all cast iron, and the crankshaft is a steel forging. Light-alloy pistons are used. Fuel consumption is just below 0·37 lb. per b.h.p.-hour at 1,500 r.p.m., and lubricating oil about 0·05 pint per hour. The oil is delivered by a rotary pump to the main gallery through a filter and from thence to the bearings and rocker gear; splash lubrication is used for the cylinder bores, gudgeon pins and tappets. Hand starting (with a decompressor) is employed. Examples of the single and twin-cylinder engines were also on display.

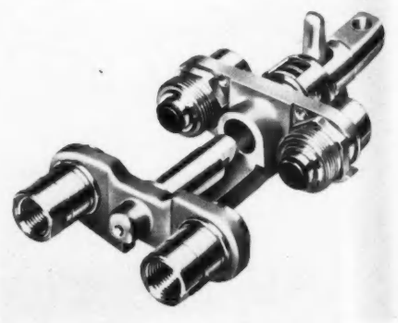

Fig. 3 "Breakaway" hydraulic hose coupling. Automotive Products Ltd.

Fig. 4 Infra-red heater. British Thomson-Houston Co. Ltd.

BREAKAWAY HYDRAULIC COUPLING

Among the many accessories exhibited on the stand of Automotive Products, Limited, Leamington Spa, which included clutches, filters and flexible hoses, was a Lockheed-Avery Breakaway coupling for use with hydraulically-controlled implements. It is illustrated in Fig. 3. This coupling has been developed to provide quick, easy connection and disconnection of hydraulically controlled farm implements from the tractor by a simple, mechanical operation completed in a few seconds; and to eliminate the breaking of hose lines, and the loss of hydraulic fluid whenever the implement breaks away from the tractor.

The coupling is a twin unit connecting both hydraulic pressure and return lines between the tractor and the implement. It consists of four self-sealing coupling halves mounted in frames, and held in a coupled position by a mechanical latch. It will separate automatically by an external tug on either of the hose lines attached to the implement, or manually by operation of the trigger. When uncoupled, both halves automatically seal, thus preventing air or dirt from entering the system and preventing any loss of fluid.

A further feature of this unit is that the breakaway halves will mate in one position only. This prevents accidental reversing or crossing of the pressure and return lines. It can also be adapted for operating single-line hydraulic accessories. The Breakaway coupling is suitable for use in all fuel, oil, water, air and hydraulic systems.

INFRA-RED HEATER

The British Thomson-Houston Company, Limited, Rugby, were showing a wide range of electrical plant including a Stavolt generating set and examples of equipment incorporating their gear. On show for the first time was a 1½ h.p. induction motor of small frame size. It is a single-phase capacitor-start machine, with the capacitor built in, for operation on 200/250 volt supplies.

Also being demonstrated was the new infra-red heating unit introduced earlier this year specially for agricultural use; this is shown in Fig. 4. A single unit is adequate for rearing an average litter of piglets from birth to six to eight weeks, or for brooding up to a hundred day-old chicks until they are eight weeks old. The unit is supplied complete with all fittings ready for installation and connection to a suitable 220-250 volt supply. It consists of a 300 watt Pyrobar dull-emitter sheathed wire element fitted to a standard Edison screw cap; an 11 in. diameter burnished aluminium reflector with a standard E.S. lamp holder; 6 ft. of suitable cable; and 5 ft. of suspension chain.

JOINING WIRES

Adams and Benson (Dalbukirk), Limited, Albion, West Bromwich, Staffordshire, were exhibiting items for steel and wire fences, both plain and electrified, and also the Foster-Clarke sugar beet harvester. A " gadget " on the stand that can ease the erection of single-strand fences, and some other operations, was the Blundell wire joiner, a tool for connecting the ends of two lengths of wire, or for making loops. Three sizes are made for handling wires up to No. 8 s.w.g. To form the joint, the two wires are held in two grooves of the jaws of a modified form of fencing pliers so that the short ends project about 1½ in. on either side. The tool is then threaded on to one short end and the wire bent at right angles. Next the tool is slightly withdrawn and moved so that the main wire enters a slot in the end of it and forms a fulcrum around which the tool is turned until the short end is completely twisted around the main wire. This is about to be done in the diagram, Fig. 5. The actions are then repeated on the other end, except that the first twist is now gripped in the pliers. The complete joint can be made in a matter of seconds and gives an excellent mechanical and electrical connection. The tool can be used equally well by a right or left-handed person.

LIGHTING POTATO HOUSES

On the stand of the General Electric Company Limited, Magnet House, Kingsway, London, W.C.2, were water-heaters for dairies, infra-red heaters for livestock houses and crop drying equipment. Of the last, a standard Transverco platform plant was displayed, so constructed that it can be used as a general purpose drier for crops such as grain, wilted grass, lucerne and legumes. The 20 hole equipment shown employs a 13 kW duct air heater and a Woods 4 B.H.P. Aerofoil fan, and has a self-contained control panel for all switches and starting gear. The average output of dried grass with this equipment is about 1–1½ tons per week, and grain can be dried at the rate of 2–3 tons per 24 hour day.

Also on show was a new fluorescent lighting fitting for conditioned potato chitting houses, designed to encourage the growth of sturdy shoots for planting. The new fittings comprise two fluorescent tubes mounted end to end and hung vertically between stacks of trays from overhead conduit. The control gear is fixed to the bottom of the fitting, and the whole assembly can easily be moved along between rows of trays as required. Two lengths of fitting are available, one with two 5 ft. 80 W tubes and the other with two 4 ft. 40 W tubes.

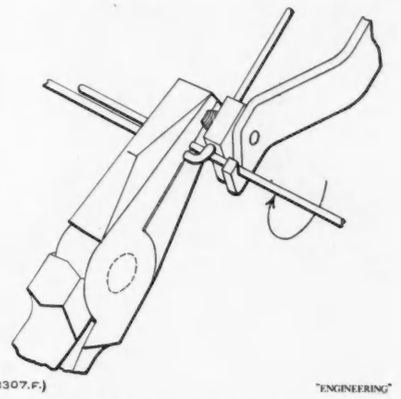

Fig. 5 Wire-joining tool. Adams and Benson (Dalbukirk) Ltd.

GLASS-FIBRE HAND TRUCK

A lightweight hand truck with a tilting body of glass-fibre laminate was being shown by Charles Pitt (Barton Stacey), Limited, Barton Stacey, Hampshire, as well as a representative selection of two and four-wheel trailers and trolleys. As may be seen in the illustration, Fig. 6, the truck consists of a three-wheel steel chassis mounted on rubber tyred wheels and a tank-shaped body which can tip on two end pins. Since the body material is glass fibre, the trailer can be used to handle almost any liquid or solid and is completely rot-proof. It is also resistant to damage by knocks or abrasion. To prevent tipping when loaded, a pin can be inserted to lock the two pivot pins in position; this pin has a jointed end which swings downwards when in position and prevents accidental withdrawal. The truck is light to handle and has a nominal capacity of 12 cwt.

MEASURING MOISTURE CONTENT

The moisture content of sacks of grain is an item of importance, and an instrument which can measure it immediately obviates the lengthy procedure of sampling. Such an instrument, which can be used without even untying the sacks, was being shown by Scottish Mechanical Light Industries, Limited, ScotMec Works, Ayr. The instrument consists of a hand-driven 500 volt generator which measures the resistance between the electrodes of a nine-pronged probe. In use, the latter is plunged into the grain to be tested—through the wall of the sack if desired—the prongs being held at their correct spacing by an insulating washer which slides along them as they enter the grain. The scale reading on the generator then shows the moisture content, which is, of course, a direct function of the resistance. Special calibrations are available for cereals, rice, coffee beans, etc. The meter was designed by Mr. Oxley, head of the Grain Storage Section of the D.S.I.R.

The firm were also showing models of their hammer-mills, of which there are some six or seven types. The range in power is from ¾ to 60 h.p. and they can be supplied with integral electric motors or internal combustion engines or for external drive. There is also one model for mounting on the three-point linkage of a tractor. Grain blowers and driers, mincers and transporters were also being displayed and there was a " husk ejector " designed as an attachment for the hammer mills to give selective grinding and allows two-qualities of meal to be ground simultaneously.

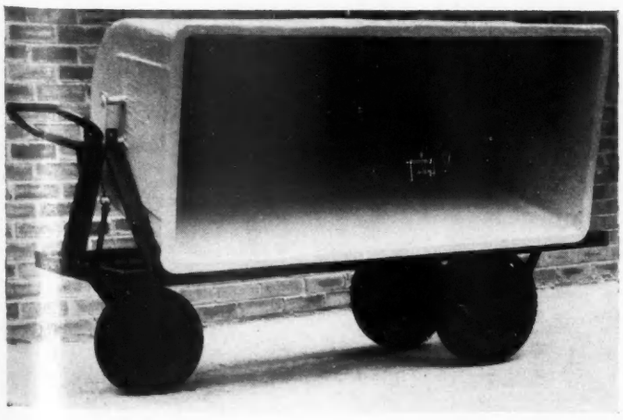

Fig. 6 Glass-fibre tipping hand truck. Charles Pitt (Barton Stacey), Ltd.

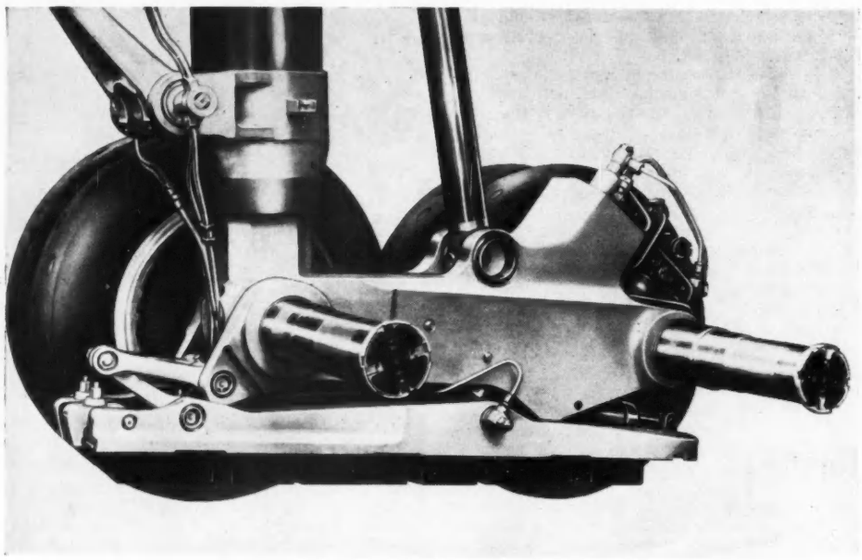

Fig. 1 The pad assembly is disposed between the wheels of the main bogie unit. Here, the near-side wheels are removed to show the pad assembly retracted. The hydraulic actuating cylinder telescopes into the bogie beam.

THE RUNWAY PAD BRAKE

HEAT DISSIPATED THROUGH CONCRETE

At the Farnborough aircraft display in September this year probably the most unconventional technical innovation was the runway pad brake shown in the static exhibition by Dowty Equipment, Limited, Cheltenham. Still under development, it has now reached the flight-testing stage and is at present installed experimentally in one of the most advanced British aircraft now flying.

The runway brake, it may be recalled, is an attempt to solve the problem of dissipating the heat generated by braking—a problem which is becoming more intractable as aircraft weights and landing speeds increase though wheel dimensions cannot be permitted to increase correspondingly. The Dowty conception is to utilise the runway itself as a heat sink by lowering on to it a flat friction pad during the landing run. The principal difficulty in realising this conception has been, naturally, in obtaining a suitable material for the pad to give the requisite high coefficient of friction with a reasonably low rate of wear and a low coefficient of heat conductivity. After a long period of research, this problem is now well on the way to being overcome, by the use of a synthetic rubber.

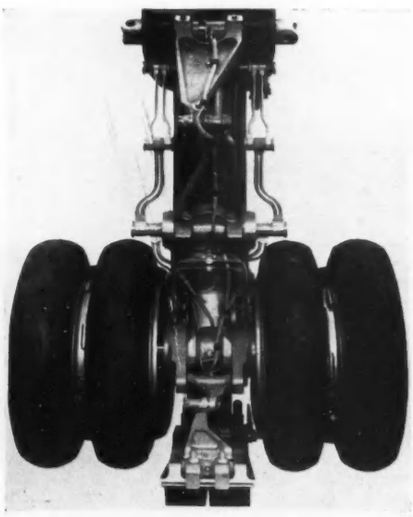

Fig. 2 Fully extended, the pad also serves to jack the wheels for servicing and replacement.

PAD TAKES 80 PER CENT. WEIGHT

As may be seen from the illustrations, the pad assembly is located between the wheels of each main bogie unit, and when the brakes are not in operation is held clear of the ground (Fig. 1). When the pilot applies the brakes, the pad is lowered so that 80 per cent. of the aircraft weight is transferred to the brake, leaving 20 per cent. still carried by the main wheels. With this arrangement, the aircraft is stable and can be satisfactorily steered by means of the nosewheel in the usual manner. If the whole of the weight were taken off the main wheels the aeroplane would become unstable unless the nosewheel were allowed to castor freely, which does not make for good control on the ground and could lead to difficulties in a cross wind.

To maintain the correct proportion of weight on the pad brake during the landing run, the main-unit shock-absorber deflection is measured and used to regulate the pressure supplied to the hydraulic brake-operating jack. The latter has a fixed piston rod and the cylinder telescopes within the bogie beam. By this means drag loads are transmitted directly through the jack to the beam. To provide cushioning for runway undulations, an air spring is incorporated with the hydraulic brake cylinder. The operating jack has sufficient travel to cover full deflection of the tyres plus the depth of pad worn away during a landing run, and when the aircraft is stationary on the ground, full extension of the brake provides for jacking the wheels off the ground thus facilitating wheel changing (Fig. 2). The pilot can apply his brakes while still airborne, but a control switch prevents the pad brake from being lowered until all four bogie wheels are on the ground. Operating time is within 0·5 second of the application of the brakes.

The brake assembly comprises three pads (Fig. 3) with herringbone slots for draining away water and worn particles of rubber, each pad being keyed and bonded to a light-alloy backing plate. Arranged to slide into tenon slots in the main brake shoe, and clamped at the leading edge, the pads can be quickly dismantled and replaced. The shoe itself is restrained from twisting in the horizontal plane by a pair of torque links at the forward end. A spring box is fitted between the rear end of the shoe and the bogie beam to ensure that the rear end comes into contact with the ground first, in order to bring the whole shoe into contact as soon as possible and to maintain dynamic stability.

ROAD TESTS ON JAGUAR

The determination of friction and wear characteristics of the pads was carried out by extensive road tests—initially fitted on a trailer vehicle but subsequently, in order to attain speeds up to 100 m.p.h., on a Jaguar car, which is still in use. A single friction pad, operated by a hydraulic jack, was mounted on the rear closed end of a W-member, the front end of which is supported on a torsion bar carrying a potentiometer. Thus the loads acting on the pad were converted by the potentiometer to voltage signals registering in the car cockpit.

No attempt was made to bring the car to rest by means of the friction pad. The procedure was to conduct a series of tests at a range of constant road speeds with the pad lowered on to the road over a measured distance. By measuring the load on the pad, the coefficient of friction could be calculated and the rate of wear determined.

The road tests are supported by tests in Dowty's hydraulic laboratory. There have been some discrepancies in the wear rates and surface temperatures experienced in full-scale tests as compared with model tests and, in order to find out more about the temperature effects, laboratory tests are now being conducted on the temperature distribution in strips of concrete heated at the surface by hot copper pads. There is still much to be learnt on the mechanism of heat transfer, and the functioning of the brake under icing conditions has still to be proved in practice. It is believed, however, that since the pad sweeps the surface of the runway clear of the lubricating water layer, the braking effect on icy runways should be substantially more effective than that of conventional wheel brakes.

Although the rate of wear of the pad brakes is high, the pads are cheap to produce and simple to replace, and since the savings in tyre wear are considerable, there is a useful gain in economy and in simplified maintenance. The runway pad brake, moreover, is claimed to be lighter than the conventional wheel brakes, by about 1 per cent. of the aircraft landing weight.

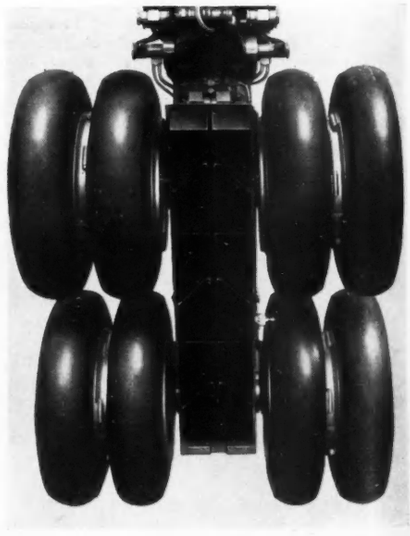

Fig. 3 The underside of the brake pad assembly, which is composed of three synthetic rubber pads bonded to backing plates, slide-mounted and clamped at the leading edge to the brake shoe for quick dismantling and assembly.

6 TON DIESEL-ELECTRIC RAILWAY CRANE

Designed to Negotiate London Transport's Tubes

The first of two Diesel-electric travelling jib cranes specially built for the London Transport Executive is now in service. It is a compact unit weighing 36 tons and, as it can be hauled in train formation through the tube tunnels at service speeds, constitutes a very effective addition to the equipment of London Transport's civil-engineering department. Previously, over a 100 miles of open track (nearly a third of the total on the system) could not be reached by rail by existing cranes for maintenance purposes, owing to load restrictions, or could be reached only by considerable detours over "foreign" lines.

The design presented difficulties because the crane was required to be within the tube loading gauge (circumscribed by a tunnel diameter of 12 ft. 0 in.); it also had to be capable of slewing a complete revolution and have a tail radius which would effectively clear cable posts, platforms, etc., while offering minimum obstruction to traffic on adjacent tracks, when working. In addition, its axle loading could not exceed 13 tons. The makers, Taylor & Hubbard Limited, Leicester, complied with this rather severe specification with considerable ingenuity, particularly in regard to the articulation of the foot of the jib, an artifice necessary for negotiating curves in the tunnels. Such articulation is provided automatically when the jib is lowered on to the jib-carrier wagon, and when raised for use the re-engagement of the foot of the jib is also fully automatic.

The working characteristics of the crane are as follow:—

To lift:

Free on rail	..	5½ tons at 15 ft. radius, decreasing to 1¼ tons at 35 ft. radius
When blocked up		6 tons at 16 ft. radius, decreasing to 2 tons at 35 ft. radius
Speeds:		
Hoisting	..	6 tons at 50 ft. per minute; 3 tons at 100 ft. per minute
Derricking	..	6 tons at 35 ft. per minute
Slewing	..	6 tons at 2 r.p.m.
Travelling	..	264 ft. per minute with 5 ton load
Stability	.. ..	In accordance with B.S.357 for Class "B" cranes

The crane incorporates an undercarriage with three axles having plain-bearing axleboxes; it is equipped with both tube-type automatic couplers and R.C.H. drawgear and hinged buffers. The swan-neck jib, which is 37 ft. long, is of rolled steel channel section, with cross-bracing. The weight is distributed between the three axles, the wheels of the middle axle being close to the trailing axle and flangeless in order to prevent fouling of the check rail on tight curves of minimum radius.

Hoisting, derricking, slewing and travelling are by means of independent 600 volt fixed space motors, via reduction gearing. The power supply is provided alternatively from a Diesel-generator set mounted on the superstructure or from a 600 volt feed obtained from the current rail of an adjacent track by means of collector shoes, trailing cable and power socket on the crane carriage. The Diesel engine is a McLaren M.R. three-cylinder unit, with a traction rating of 75 h.p. at 1,000 r.p.m., coupled to a 49½ kW compound-wound generator made by Lancashire Dynamo & Crypto, Limited. The engine has two control speeds—idling and full speed. Electro-mechanical solenoid brakes are fitted to both the hoist and derricking motions. The hoist brake has a hand release from the driving position to enable the operator to lower by gravity or to set down the load immediately in an emergency. A hand-lever release on the derrick brake allows the boom to be lowered by gravity on to its carrier wagon in the event of failure of the derrick motor. Slewing and travelling brakes are of the foot-operated band type.

The control gear has been made by Howell and Company, Limited, the controllers being cam-operated contactors operated by vertical lever gear in the driver's cab. Limit switches have been provided in the hoisting motion to prevent over-winding, and in the derricking motion to limit the amount of travel in both directions. A safe-load indicator is fitted in the derrick rope and gives visible and audible warning of both "free-on-rail" and "blocked up" conditions. A colour light panel (with traffic-light pattern sequence) is situated to the front and right of the driver, and a further panel, mounted outside the superstructure on the extreme left front, gives warning to men working at the load. This indicator operates from the 24 volt starter battery, which is charged from a generator off the Diesel engine, or alternatively from a separate motor-generator set when the crane is operating from the track current supply. The engine is equipped with cartridge starting equipment for use should the battery be run down.

Westinghouse air brakes are fitted to the jib carrier wagon, and through-pipes to both the crane and carrier for use when travelling in train formation. An electric horn gives warning of travel movements. A jib cluster of five 60 watt 24 volt lamps is provided, as well as cabin lights and side lights to illuminate the propping gear.

London Transport's new 6 ton breakdown crane has been designed within the loading gauge of standard tube stock and, with jib lowered on to a carrier wagon, is able to travel through the Executive's tunnel system. To traverse the sharpest curves, the lowered jib is articulated at its foot.

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CHRISTMAS LECTURES FOR JUNIOR AUDIENCES

"Big Molecules" has been chosen as the title for this year's series of Christmas lectures at the Royal Institution, Albemarle-street, London, W.1. They form the 126th course, specially "adapted to a juvenile auditory," for delivery at the Institution.

Starting with an explanation of the methods by which large molecules are constructed from small ones, the lecturer, Professor H. W. Melville, F.R.S., will proceed to consider in subsequent lectures the size of a "big molecule"; rubber and the rubber-like state; and man-made fibres. The last two lectures of the series will be devoted to "Plastics from Big Molecules." The six lectures will be delivered on December 27, 29 and 31, 1955, and January 3, 5 and 7, 1956, commencing at 3 p.m., and the subscription to the course will be 20*s.* for juveniles (aged 10 to 17) and £2 for other non-members of the Institution.

A Christmas lecture has been arranged, for the tenth year, by the Institution of Electrical Engineers. This lecture will be on "Electric Traction," and will be delivered by Mr. R. Brooks, B.Sc., M.I.E.E., at the headquarters of the Institution, Savoy-place, Victoria-embankment, London, W.C.2, on December 29, 1955, at 3 p.m., and again on the following afternoon, at the same place and time. The lecture, which is suitable for young people aged 14 to 18, will also be delivered by Mr. Brooks at the College of Technology, Sackville-street, Manchester 1, on January 6, 1956, and at the Royal Technical College, Peel Park, Salford, on January 7, 1956, in each case commencing at 3 p.m.

Lectures, intended primarily for boys aged 13 to 17, have also been arranged by the Institution of Civil Engineers, Great George-street, London, S.W.1. It is hoped that one lecture will deal with atomic energy and the other with railways of the future. They will be delivered on December 28 and 29, respectively, commencing at 3 p.m.

Arrangements for the lectures at Manchester and Salford are in the hands of Mr. T. T. Evans, 9 Kingston-drive, Sale, Cheshire. Applications for tickets for the other lectures may be made to the secretaries of the Institutions concerned at the addresses given. Except in the case of the Royal Institution, tickets are free.

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REACTOR PRESSURE VESSELS

Units for Calder Hall and Chapelcross

At Calder Hall all major work on the second of the two reactor vessels in the Calder Hall A station has been completed by the contractors, Whessoe Limited, of Darlington. The entire vessel has now been welded and stress relieved and has been pressure tested with satisfactory results. Like its fellow, this vessel is approximately 60 ft. high and 40 ft. in diameter. Constructed in steel 2 in. thick it weighs over 400 tons. Each vessel constitutes a major step in steel-plate engineering, and, since the carbon-dioxide coolant circulating through the reactors will be at about 100 lb. per square inch (not, as stated on page 740 of our issue of November 25, 100 tons per square inch) the vessels must be constructed to withstand pressures of at least this value. The vessels embody unusual features of design, metallurgy and fabrication.

Whessoe Limited have orders from the United Kingdom Atomic Energy Authority for six more such vessels, two for the Calder Hall B station and four for the Chapelcross power station. Whessoe Limited, are a member firm of the Nuclear Power Plant Company, set up this year to design and build complete nuclear power stations.

British Nuclear Energy Conference (concluded from page 805)

POWER FOR THE FUTURE

NUCLEAR ENERGY: PLANNING, HEALTH AND RESEARCH

In the conclusion of our article summarising the papers presented at the inaugural meeting of the British Nuclear Energy Conference, we cover the final part of a paper prepared by Mr. V. A. Pask and Mr. J. C. Duckworth dealing with the contribution of nuclear energy to United Kingdom power development; a paper by Dr. A. S. McLean and Dr. W. G. Marley on health and safety; and a paper by Mr. H. J. Grout on research reactors. The meeting was held at the Institution of Civil Engineers on November 30.

FAST REACTOR

Continuing the paper, of which he was joint author with Mr. Duckworth, Mr. Pask stated that the U.K.A.E.A. were developing a prototype fast reactor which was expected to give a definitely positive gain factor on the U238–Pu239 cycle. The difficulties connected with the fast reactor were formidable. The absence of moderator gave a very small core; the core consisted largely of pure fissile material, which was very expensive and the core must, therefore, be given a high heat rating. The need to generate 100 MW. of heat in a cylinder 2 ft. long by 2 ft. in diameter was an indication of the kind of heat-transfer and metallurgical problems encountered.

However, it was possible in the future that a power reactor system would be able, by judicious combination of types, to produce all the fissile material it required; fuel costs would be reduced to the cost of the chemical and metallurigcal processes involved in re-cycling the fissile material, together with the cost of a feed of fertile material.

Any assessment of the capital costs associated with later years of the C.E.A. programme would be extremely speculative. A continuing increase could be foreseen in reactor heat ratings through improved versions of the gas-cooled reactors to the more advanced types. Capital costs should therefore continue to decline although the necessity to develop new techniques and the demand for exotic and little known materials might in some degree offset the improved heat ratings.

C.E.A. PLANNING

After this consideration of the probable magnitude of future nuclear plant requirements, its impact on C.E.A. system planning was briefly examined. The main 275 kV system as now planned for 1960 comprised about 2,500 circuit miles inter-connecting the major load and generation centres. The greater part of this network was required for the pooling of spare generating plant, but the programme of new generating-plant installations between now and 1960 envisaged the generation of part of the base load for the south of the country, where little coal was produced, by high-efficiency plant installed in the coal-producing East Midlands area, utilising the River Trent for cooling water. Three of the six 275 kV circuits planned from the Midlands to the south would be provided for this bulk transmission, the remaining three being required for interconnection purposes.

The alternative to this bulk transmission of electricity from the coalfields would be to build stations of an equivalent capacity in the Thames Estuary, and bring coal to them by rail and sea from the East Midlands coalfields. As a major part of the load growth in the south would occur to the west of London, bulk transmission of the output of these stations would in any case be necessary for a distance of about 70 miles. The proposal adopted—bulk transmission to the south from the East Midlands coalfields—was expected to result in net annual savings exceeding £1 million; and if there were no prospective shortage of home-produced coal further development of bulk transmission would undoubtedly yield a handsome return.

CONDITIONS OF SITING

The prospect of meeting a large part of future electrical energy requirements by nuclear generation, however, radically altered the picture of future economic development. The tendency would be to site the nuclear plant in areas where insufficient coal was mined to meet local requirements, and as near as possible to the major load centres. The three essential requirements for a site for a gas-cooled graphite-moderated nuclear power station were a sub-soil capable of adequately supporting loads of up to 3 tons per square foot, good road access, and an adequate supply of cooling water for the condensers of the steam plant. Although this type of reactor was inherently stable and there was negligible risk to people outside the boundaries of the site, the Government had wisely decided that the first stations would not be erected in heavily built-up areas; this would give the public time to realise that nuclear power was fundamentally safe.

Later, more advanced reactors would probably require containing envelopes to guard against the possible escape of radioactive particles from the core in case of accident, but it was too early to be dogmatic about their siting. However, it was certainly expected that, in the course of time, siting the more advanced reactors close to major built-up areas would present no dangers.

HEAVY COOLING WATER DEMANDS

The availability of cooling water would probably impose greater restriction on freedom of siting than safety aspects, since there were few rivers in England of sufficient size to serve major concentrations of generating plant. Most stations might later therefore have to be sited on estuaries or on the coast, whatever the source of heat supply to the stations might be. The transport of the relatively small quantities of used fuel elements by road to the processing factories was not expected to offer any serious difficulty. By storing the used elements for a period to allow partial decay of radioactivity, the protection required during transport would be kept within reasonable limits.

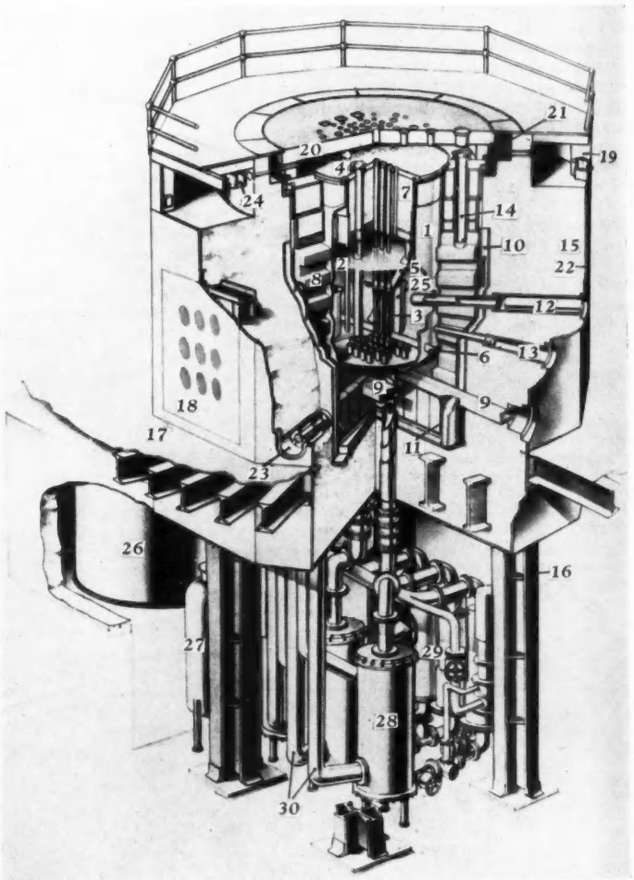
LOAD FACTOR

As the nuclear plants would for economic reasons be operated at high load factor they would gradually take over the generation of the continuous demand. It followed that transmission of electrical energy generated from coal in the coal-producing areas would eventually be impossible at high load factor and therefore uneconomical. As the system demands increased, however, the transmission interconnection requirements for the pooling of spare plant would also increase and the indications were that this would fit in well with the present plans for future system development, since by the early 1970's, on present expectations, all the additional transmission circuits planned for bulk transmission at peak from the Midlands coalfield area in the 1960's would be absorbed as interconnection capacity for the pooling of spare generating plant.

HEALTH AND SAFETY

In the paper "Health and Safety in the Nuclear Power Industry" prepared by Dr. McLean and Dr. Marley, the authors stated that it was greatly to the credit of the leaders of atomic energy development that theirs was probably the first major industry to adopt a vigorous attitude to health and safety as one of its primary and most important terms of reference. It had been shown that thoroughly effective protection could be provided for workpeople and those living in the neighbourhood of atomic installations, but it was urgently necessary to share that confidence and present the facts about radiation in simple language. By the criterion of absences, the incidence of disease among atomic energy workers was below normal and in the U.K.A.E.A. no case of radiation injury had occurred. Continuous individual measurements of external radiation exposure showed an average approximately one-thirtieth of the maximum permissible level, and the corresponding figure for internal contamination was even less.

No precise relationship between radiation dose and genetic effect had been established for the human species, and it was unlikely that a real correlation would be forthcoming for many years. The only comparison was with natural radiation to which the human race was constantly subjected. The aggregate gonad dose of natural radiation received by the population of this country was about 5,000,000 man-rads annually. The additional dose from all diagnostic X-ray examinations was about 5 per cent.



1. Reactor aluminium tank containing heavy water.
2. Heavy-water level.
3. Fuel element.
4. Vertical experimental hole thimble.
5. Control signal arms, six in number.
6. Experimental hole 4 in. by 2 in.
7. Top biological shield.
8. Graphite moderator.
9. Experimental holes 12 in. by 8 in.
10. Lead thermal shield (water cooled).
11. Reactor steel tank with boral sheet lining.
12. Experimental hole entering heavy-water zone.
13. Experimental hole entering graphite zone.
14. Vertical experimental hole entering graphite zone.
15. Concrete biological shield.
16. Reactor supporting structure.
17. First floor.
18. Thermal column.
19. Hollow stanchions communicating with base of reactor.
20. Steel top plate (10 in. thick).
21. Duct for experimental services.
22. Biological shield casing plate.
23. Ion chamber.
24. Fine control rod gearbox.
25. Heavy-water outlet pipe.
26. Heavy-water storage pipe.
27. Heavy-water safety dump tank.
28. Heavy-water heat exchangers.
29. Heavy-water main circulation pump.
30. Secondary cooling-water piping (to coolers).

Fig. 4 Sectioned view of high-flux heavy-water research reactor DIDO, showing details of construction. (A.E.R.E. drawing).

of that figure, and the contribution of the atomic energy industry amounted to about 0·05 per cent. There was a total of 50,000 man-years cumulative experience in the United Kingdom's nuclear industry and by comparison with the agricultural, engineering and chemical industries five deaths might have been expected. In fact, only one death had occurred and that as the result of a 50 ft. fall.

However, locked up in the uranium metal fuel elements of a large nuclear reactor there might be million curie quantities of radioactivity. The possible consequences of a large-scale release of activity in the event of accident had long been recognised as an important factor in the development of nuclear power. It was considered, however, that an adequate degree of containment could be maintained.

RESEARCH REACTORS

The last paper, "The Use of Research Reactors in Nuclear Power Development," was presented by Mr. H. J. Grout, who stated that the purpose of research reactors was to provide both the radiation-field and test-bed facilities to enable the behaviour of reactor materials and components to be studied and tested under simulated operating conditions and to obtain fundamental information in the fields of reactor physics, chemistry and metallurgy. The investigations carried out included fundamental measurements in metallurgy, irradiation effects on uranium, neutron diffraction techniques, fundamental measurements in chemistry, reactor-shielding tests, and fundamental measurements in physics. Among the physical quantities studied were uranium and isotope cross-sections, build-up of fission-product poisons, absorption and scattering cross-sections of new structural materials, and numbers of neutrons produced per neutron captured. Another subject considered was the development of fuel elements.

A fuel element could be described as a rod, tube, or plate of fissile-containing material in the form of natural or enriched uranium, possibly alloyed and contained in a sheath. Table VI indicates the factors which must be considered in developing a fuel element for a particular type of reactor. It shows the degree of interaction between the various factors.

HOT LOOPS

Although it is true that much engineering research, including the development of special components, could be done in the conventional manner, there was the need to test predictions and components under working conditions. A research reactor, if designed to do this, did enable the engineer to build up in a suitable facility a pilot-sized installation complete with fuel elements, coolant circuit and specialised instrumentation. These "active hot loops" were certain to play a major part in nuclear power development during the next decade.

To illustrate the scope and function of the hot loop, it was possible to consider a power reactor based on the use of pressurised light water as a moderator and coolant, with low-enrichment uranium as fuel in a zirconium-stainless-steel circuit. Some of the problems involved in design and construction of such a reactor were: (i) corrosion of the circuit

TABLE VI.—*Factors Affecting Design and Fabrication of a Fuel Element*

Field of study	Points to note
Sheath	
Nuclear physics ..	Absorption, and in fast reactors scattering cross-sections as affecting core design.
Compatibility ..	With coolant, fuel material, thermal bond material and coolant-circuit materials; effect of sheath failures.
Fabrication	Suitability for quantity production; sealing methods.
Heat transfer ..	Extended fin surfaces; thermal bond with fuel material; temperature stresses.
Operational requirements	Method of charge and discharge from reactor; robustness.
Re-processing ..	Stripping or dissolving of sheath; long-term activities; value of scrap.
Thermal bond	
Nuclear physics ..	As before; also effect of fission products from fuel material.
Compatibility ..	As before.
Method of achievement	By direct contact between sheath and fuel; by inter-metallic bonding; by layer of high-conductivity material.
Fabrication	Suitability for quantity production.
Re-processing ..	Must be taken into account.
Fuel material	
Nuclear physics ..	Effect of alloys on competitive cross-section.
Compatibility ..	As before.
Material	Enrichment and alloying.
Effect of irradiation ..	"Burn-up"; structural changes.
Fabrication and form	Whether by casting, rolling and extrusion, etc., machining and heat treatment.
Heat transfer ..	Temperature distribution; thermal stresses and effects of temperature cycling.
Re-processing ..	Must be taken into account.

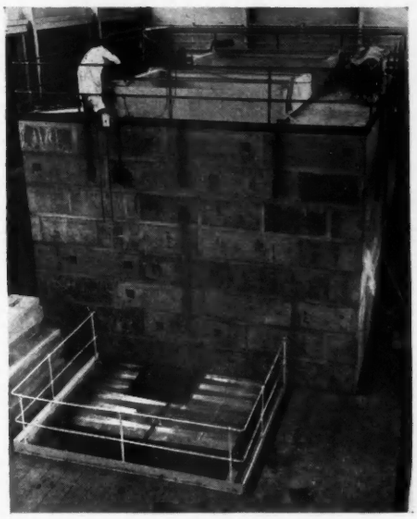


Fig. 5 The uncooled fast reactor ZEUS (shown here with biological shield in place) is a full-scale model of the fast breeder reactor under construction at Dounreay. (A.E.R.E. photograph)

and fuel element material in the presence of intense radiation; (ii) mass transfer of material leading to fouling of the coolant passages and high activity outside the core zone; (iii) decomposition of the coolant due to neutron and gamma radiation; (iv) control of water purity by ion-exchange to reduce corrosion; (v) detection of "burst" fuel elements in a water circuit; (vi) heat transfer and pressure drop under reactor operating conditions; (vii) behaviour of fuel elements as the result of fissile material burn-up and temperature gradients; and (viii) performance of special components, pumps, valves, heat exchangers and instrumentation.

An active hot loop would consist of a number of prototype fuel elements in a coolant system, complete with pumps, heat-exchangers, ion-exchange system, and instrumentation. The fuel-element section would be built into an experimental hole in a research reactor such that the neutron-flux level in the region would cause the elements to operate at their designed rating. A pressurised-water loop of the type described is already in operation in BEPO at Harwell.

CHOOSING A SYSTEM

From Table VII it can be seen that: (i) graphite natural-uranium systems provide a large volume of experimental space but the neutron flux per MW is low, and excessively large and powerful systems would be needed for technological work; (ii) the heavy-water natural-uranium system provides fluxes high enough for technological work and reasonable experimental volume, but the reactor tends to be of high power and thus rather expensive; where, however, ample supplies of ready-to-use cooling water are available, this system is attractive; (iii) the enriched-uranium graphite light-water cooled system is an example of one of the many possible variants that can be used for experiment, once an adequate supply of enriched uranium is available; (iv) enriched-uranium heavy-water moderated and cooled systems provide intense neutron fluxes for a low power output, the experimental volume is small, although the use of a heavy-water reflector with low absorption considerably increases the volume available; (v) enriched-uranium light-water moderated and cooled systems are similar to (iv), but the high-flux zone is very restricted unless use is made of a thick beryllium reflector as in MTR.

Mr. Grout continued by considering the factors in choosing a research reactor for a given purpose. For technological irradiations involved in the development of fuel elements, the testing of reactor materials and the installation of engineering loops, an experimental flux greater than 5×10^{13} neutrons per square centimetre per second was required together with large volume. The choice clearly lay between the enriched-uranium and the heavy-water moderated natural-uranium systems such as NRX, and a balance had to be struck between the potential higher flux available in the former against the larger experimental volume of the latter, taking into account other factors such as cost, siting and availability of material.

In the United Kingdom it had been decided for the time being to concentrate on the enriched-uranium system moderated with heavy water, although the rather higher ratio of fast to thermal flux with light-water moderation might prove of interest and make it desirable to have a reactor of this type eventually, despite its restricted experimental volume.

For general research purposes where a high flux was necessary for rapid progress and good resolution, the enriched-uranium heavy-water system was preferred. For its size it had a fair experimental volume and the moderate power enabled it to be sited adjacent to a research station provided that reasonable containment was assured.

The requirements for cross-section measurements involving swing methods called for a small reactor of low power with stable characteristics. A graphite air-cooled system with low-enrichment material was likely to be the best choice. For shielding studies a flux of 10^{12} was adequate and the special features of the swimming-pool type reactor made it a desirable vehicle for this type of investigation.

Two United Kingdom research reactors are shown in the accompanying illustrations. Fig. 4 is a sectioned perspective drawing of the high-flux heavy-water reactor DIDO, showing details of its construction; and Fig. 5 is a view of the uncooled fast reactor ZEUS (Zero Energy Uranium System) with the biological shield in position.

EXPERIMENTAL PROTOTYPES

Nevertheless the pattern of future technical development was sufficiently clear for some general observations to be made on the role of the research reactor during the next decade. In the immediate future the need was for high-flux materials-testing reactors, with facilities for loop testing on a pilot-plant scale to support the development of solid-fueled thermal reactors operating at about 2 MW per kg. of fissile material (equivalent to a neutron flux of 5×10^{13}). However, once prototype and production reactors had been built and operated they would themselves largely take over the present rather special role of the research reactor in this field.

The development of more sophisticated power systems such as the homogeneous fast breeder and thermal reactors using liquid-metal fuel slurries, all of which must operate at very high ratings, would pose special problems. Consequently, although the research reactor as it was known now would play a vital role in the preliminary development, the tendency might well be towards the construction of specially designed prototypes.

In the U.K. there might well be a need in the future for at least one research reactor of the conventional type providing a neutron flux approaching 5×10^{14} with rather larger experimental facilities than had been contemplated up to the present.

TABLE VII.—CHARACTERISTICS OF VARIOUS REACTOR SYSTEMS

Fuel	Moderator	Coolant	Fuel investment	Max. neutron flux per MW	Core volume, cub. ft.	Amount of fissile material, kg. per cub. ft. of core	Practical upper limit of flux	Examples built or under construction
Natural uranium..	Graphite	Air	40 tonnes	$2{\cdot}0 \times 10^{11}$	6,000	0·05	10^{13}	Oak Ridge, Brookhaven } U.S.A. B.R.I., Belgium. BEPO, U.K.
Natural uranium..	D_2O	D_2O or H_2O	10 tonnes	$1{\cdot}5 \times 10^{13}$	500	0·15	10^{14}	NRX, Canada
Enriched uranium	Graphite	H_2O	10 kg. U235	$0{\cdot}8 \times 10^{13}$	30	0·35	5×10^{14}	R.P.T. research reactor (Reactor for Physical and Technological Research), U.S.S.R.
Enriched uranium	D_2O	D_2O	2·5 kg. U235	$1{\cdot}0 \times 10^{13}$	12	0·5	5×10^{14}	DIDO, PLUTO } U.K. CP5, U.S.A.
Enriched uranium	H_2O	H_2O	4·5 kg. U235	$1{\cdot}0 \times 10^{13}$	3	1·5	5×10^{14}	LITR, MTR and others proposed in U.S.A.
Enriched uranium	Homogeneous system		1·0 kg. U235	$4{\cdot}0 \times 10^{13}$	0·5	2·0	10^{15}	Only small units built, e.g., U.S.A. SUPO at 45 kW.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"The Heat Pump, with Special Reference to Domestic Installations," by G. Peter Watson. London National Lecture. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Dec. 20, 6.30 p.m.*

PORTSMOUTH
"Electricity in the Aircraft Industry," by W. A. Pile. Portsmouth Branch. 598 Commercial-road, Mile End, Portsmouth. Tues., Dec. 20, 7.30 p.m.

British Institution of Radio Engineers

LONDON
"Domestic Tape-Recording Applications, with Special Reference to Stereophonic Reproduction," by M. B. Martin and D. L. A. Smith. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Thurs., Jan. 5, 6.30 p.m.

LIVERPOOL
"Electronic Instrumentation for Nuclear Power," by R. J. Cox. Merseyside Section. Chamber of Commerce, 1 Old Hall-street, Liverpool, 3. Wed., Jan. 4, 7 p.m.

MANCHESTER
"Radio and Television Interference: Its Growth and Effects," by M. Smith. North Western Section. College of Technology, Sackville-street, Manchester. Thurs., Jan. 5, 6.30 p.m.

Building Centre

LONDON
Films on Modern Timber Work: "Engineered Timber Construction," and "Sylvaply To-Day." Wed., Dec. 21, 12.45 p.m.

Illuminating Engineering Society

LONDON
"Recent Developments in Photometry and Colorimetry," by G. T. Winch. Royal Society of Arts, John Adam-street, W.C.2. Tues., Jan. 10, 6 p.m.

BRISTOL
Various short papers on lighting installations. Bath and Bristol Centre. Royal Hotel, Bristol. Fri., Jan. 6, 7 p.m.

CARDIFF
"X-Rays in Medicine and Industry," by K. Rawlings. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 5, 5.45 p.m.

GLASGOW
"Lighting Problems in the Coal Industry," by W. Rochester. Glasgow Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 5, 6.30 p.m.

HULL
"Street Lighting," by J. J. French. Leeds Centre Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., Jan. 9, 7 p.m.

LIVERPOOL
"Lighting in the Rayon Industry," by G. E. Shepherd. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Tues., Dec. 20, 6 p.m.

Incorporated Plant Engineers

LONDON
Debate: "That our Main Railways be Converted into Roads." Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Jan. 3, 7 p.m.*

BIRMINGHAM
Problems Evening. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Dec. 30, 7.30 p.m.

CARDIFF
Film: "Steam and Utilisation." South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Dec. 20, 7.15 p.m.

DUNDEE
"Hospital Services," by C. N. Anderson. Dundee Branch. Mathers Hotel, Dundee. Mon., Jan. 9, 7.30 p.m.

EDINBURGH
"Materials Handling," by J. Findlay. Edinburgh Branch. 25 Charlotte-square Edinburgh. Tues., Jan 10, 7 p.m.

MANCHESTER
Discussion on "Power Factor Correction." General Meeting. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Jan. 10, 7.15 p.m.

SOUTHAMPTON
"Costing and Accountancy in Relation to Plant Engineering," by S. J. Clark. Southern Branch. Polygon Hotel, Southampton. Wed., Jan. 4, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
"The Use of Refractories in the Foundry," by W. E. Ambler. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Jan. 7, 6.30 p.m.

IPSWICH
Film Evening. East Anglian Section. Public Library, Ipswich. Tues., Dec. 20, 7.30 p.m.

Institute of Fuel

LONDON
"Some Coal Research Problems and Their Industrial Implications," by R. L. Brown. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 4, 5.30 p.m.*

Institute of Industrial Supervisors

LIVERPOOL
"Shop Floor Economics," by F. Lowson. Merseyside Section. Stork Hotel, Liverpool. Wed., Dec. 21, 7.45 p.m.

Institute of Marine Engineers

LONDON
"Nuclear Power for Commercial Vessels," by Kenneth Maddocks. Tues., Dec. 20, 5.30 p.m.*

GLASGOW
"Nuclear Power for Commercial Vessels," by Kenneth Maddocks. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 29, 7.30 p.m.

Institute of Petroleum

ROCHESTER
Annual General Meeting and Film Display. South Eastern Branch. King's Head Hotel, Rochester. Tues., Jan 3, 7.30 p.m.

Institute of Refrigeration

LONDON
"Refrigeration Controls," by H. H. Egginton. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 5, 5.30 p.m.*

Institute of Welding

LONDON
"Brittle Fracture of Mild Steel: A Survey," by Dr. Constance F. Tipper. North London Branch. Manson House, 26 Portland-place, W.1. Wed., Jan. 4, 7 p.m.*

Institution of Civil Engineers

LONDON
"The Diversion of the Annalong River into the Silent Valley Reservoir," by Dr. C. F. Colebrook. Works Construction Division. Tues., Dec. 20, 5.30 p.m.*
"Reconstruction of the Gallions Entrance Lock at the Royal Docks of the Port of London Authority," by J. A. Fisher. Maritime and Waterways Division. Tues., Jan. 3, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Highland Water Power: The Development of the North of Scotland Hydro-Electric Board," by the late T. Lawrie. Thurs., Jan 5, 5.30 p.m.*
"Power-Station Auxiliary Plant," by G. F. Kennedy and F. J. Hutchinson. Joint Meeting with the Institution of Mechanical Engineers. 1 Birdcage-walk, St. James's Park, S.W.1. Fri., Jan. 6, 5.30 p.m.*

GLASGOW
"Automatic Circuit Reclosers," by G. F. Peirson, A. H. Pollard and N. Care. South West Scotland Sub-Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Jan 4, 7 p.m.

LEEDS
"The Electrical-Engineering Industry in the Post-War Economy—II," by G. L. E. Metz. North Midland Centre. Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 3, 6.30 p.m.

MANCHESTER
"Highland Water Power: The Development of the North of Scotland Hydro-Electric Board," by the Late T. Lawrie. North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Jan. 3, 6.15 p.m.

NEWCASTLE-UPON-TYNE
"A Criterion of Distribution Cost," by D. J. Bolton. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 9, 6.15 p.m.

PORTSMOUTH
"Receiving Aerials for British Television," by F. R. W. Strafford. Southern Centre. College of Technology Extension, Portsmouth. Wed., Jan. 4, 6.30 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Mechanical Services in the British European Airways Hangars at London Airport," by L. Copeland Watts and J. W. J. Leslie. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Thurs., Jan. 5, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Power-Station Auxiliary Plant," by G. F. Kennedy and F. J. Hutchinson. Joint Meeting with the Institution of Electrical Engineers. Fri., Jan. 6, 5.30 p.m.*
"Some Notes on Carburation and Allied Problems," by C. H. Fisher. Automobile Division. Tues., Jan. 10, 5.30 p.m.*

GLASGOW
"Heat Losses in Internal-Combustion Engines," by Dr. A. S. Leah. Scottish A.D. Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Dec. 19, 7.30 p.m.

LEICESTER
Annual General Meeting. Thomas Hawksley Lecture on "The Properties of Matter at High Pressures," by Professor D. M. Newitt. East Midlands Branch. College of Technology, Leicester. Tues., Jan 10, 6.30 p.m.

Institution of Production Engineers

DERBY
"Fundamentals of Progressive Tooling," by J. A. Grainger. Derby Section. College of Art, Derby. Mon., Dec. 19, 7 p.m.

NEWCASTLE-UPON-TYNE
Film Evening. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Dec. 19, 7 p.m.

NOTTINGHAM
Informal Discussion Meeting. Nottingham Section. Victoria Station Hotel, Nottingham. Wed., Jan. 4, 7 p.m.

OXFORD
"Cost Accounting as an Aid to Efficient Production," by H. J. Furness. Oxford Section. Town Hall, Oxford. Tues., Jan. 3, 7.15 p.m.

SOUTHAMPTON
"Economic and Social Effects of Automation," by R. R. Williams. Southern Section. The University, Southampton. Thurs., Jan. 5, 7.30 p.m.

WOLVERHAMPTON
"Forgings and Pressings in High-Strength Aluminium Alloys," by J. E. Earl. Wolverhampton Section. Wed., Jan. 4, 7.15 p.m.

Institution of Railway Signal Engineers

BRISTOL
"Signalling in Relation to Braking Performance," by O. S. Nock. Staff Canteen, Approach-road, Temple Meads Station, Bristol. Wed., Dec. 21, 6 p.m.*

YORK
Open Meeting to be held jointly with the Permanent Way Institution. Railway Institute, York. Tues., Jan. 10, 5.30 p.m.*

Institution of Structural Engineers

LONDON
"Engineering Problems in the Docks," by G. A. Wilson. London Graduates' and Students' Section. Mon., Dec. 19, 6.30 p.m.
Discussion on "Engineering in Europe and America." London Graduates' and Students' Section. Wed., Jan. 4, 6.30 p.m.

BRISTOL
Open Meeting. Western Counties Branch. The University, Bristol. Fri., Jan. 6, 6 p.m.

LEEDS
"Geophysical Methods of Exploration and Their Application to Structural Engineering Problems," by J. Robertshaw. Yorkshire Branch. Great Northern Hotel, Leeds. Wed., Dec. 21, 6.30 p.m.

NEWCASTLE-UPON-TYNE
Open Meeting. Northern Counties Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Jan. 4, 6.30 p.m.

Institution of Works Managers

BIRMINGHAM
"Management as Seen from the Shop Floor," by L. Pridmore. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Jan. 10, 7 p.m.

Junior Institution of Engineers

LONDON
Question and Discussion Evening. Fri., Dec. 30, 7 p.m.
Film Evening. Fri., Jan. 6, 7 p.m.

BIRMINGHAM
"Josiah Wedgwood: The Potter," by Miss R. J. Warne. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Jan. 4, 7 p.m.

Manchester Association of Engineers

MANCHESTER
"Polythene and Its Uses," by A. Renfrew. Engineers' Club, Albert-square, Manchester. Fri., Jan. 6, 6.45 p.m.

Reinforced Concrete Association

LIVERPOOL
"Selection and Grading of Aggregates for Various Types of Concrete Works," by J. D. McIntosh. North Western Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Jan. 4, 6.30 p.m.*

MANCHESTER
"Selection and Grading of Aggregates for Various Types of Concrete Works," by J. D. McIntosh. North Western Branch. College of Technology, Sackville-street, Manchester. Tues., Jan. 3, 6.45 p.m.*

Royal Aeronautical Society

LONDON
"Recent Advances in Aircraft Adhesives," by Dr. N. A. de Bruyne. Section Lecture. Tues., Dec. 20, 7 p.m.
"Test Flying: Current Problems and Techniques," by Wing Commander R. P. Beamont. Young People's Lecture. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Jan. 5, 3 p.m. (Tea at 4.30 p.m.)

Royal Meteorological Society

LONDON
"Free and Forced Convection in the Atmosphere near the Ground," by C. H. B. Priestley; and "An Operational Frontal Contour Analysis Model," by R. Anderson, B. W. Boville and D. E. McClellan. Wed., Dec. 21, 5 p.m.*

Royal Society of Arts

LONDON
"How Clocks and Watches Work," by A. W. Marshall. Fri., Dec. 30, 2.30 p.m.

Royal Statistical Society

LONDON
"Explanatory Approaches with Observational Data," by Professor H. Wold. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Dec. 21, 5.15 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, 6.30 p.m. "The Use of Statistical Design in Chemical Analysis," by G. A. Coutie, 7 p.m. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 10. Tues., Jan 10.

Society of Instrument Technology

LONDON
"Liquid-Flow Control," by B. W. Balls. Control Section. Manson House, 26 Portland-place, W.1. Thurs., Jan. 12, 7 p.m.*

FAWLEY
"Metals and Their Uses" and "X-Rays with Metals," by Val Cotton. Fawley Section. Copthorne House, Fawley, Hants. Fri., Jan. 6, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Industrial Supervisors, 24 Albert-street, Birmingham 4. (Midland 6971.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane 6851.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, Lonon, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield 7. (Sheffield 53674.)
Society of Instrument Technology, 184 Sherwood Park-road Mitchem, Surrey. (POLlards 3620.)

In Parliament

DEBATE ON NOISE

By directing public attention at the present time to one of the most urgent problems of the industrial age, the recent debate in the House of Commons on noise has served a useful purpose and may well be expected to exercise a beneficial influence. Editorial comment on this problem is contained in a leading article on page 809.

The debate was opened by Sir Lionel Heald, Q.C. (Unionist), who moved that the House noted with concern the detrimental effect of noise and vibration on the health, well-being and efficiency of the nation; and urged the Government to give careful attention to the importance of research and education in this field, and to more effective measures for the protection of the public. He defined noise, quoting from an Australian Act of Parliament of 1928, as "a loud or harsh sound, or a din, or a disturbance made by one or more persons," and said that this seemed essentially the kind of problem suitable for a private member's motion, since it was the type of difficulty which Governments were apt to ignore until some pressing reason arose as to why they should cease to ignore it.

In certain circumstances, and especially among the young, some noises were approved. A really good brass band was a case in point. Again, there were people who might consider the problem to be so difficult that there was no use in trying to do anything about it. But many people had tried and failure to appreciate their efforts would be unfair to the pioneers in medicine, science and industry who had expended a great deal of time, energy and money on this subject. Some splendid work had been done in the Building Research Station at Garston, which is part of the Department of Scientific and Industrial Research. Aircraft manufacturers, such as Vickers Limited, the de Havilland Company and others, had also done good work. At Vickers works at Brooklands, where Valiant aircraft were under construction, silencers were brought up behind the jets, like vast pantechnicons, and these instruments had a very beneficial effect in minimising the noise which was made when the engines were being tested.

Government regulations in respect of road vehicles had been largely unsuccessful. Sir Lionel quoted from a Government report issued in 1936, which stated that it was evident that the high performance of motor bicycles "had outstripped the art of silencing them." He noted that, in 1937, the then Minister of Transport had expressed his willingness "to receive a deputation of interested parties to protest against the proposed silencer regulations." Coming to more modern times, it seemed rather striking that no separate records were kept of silencer offences. Other examples of road noises referred to by Sir Lionel included the unloading of steel scaffolding and the operations of road drills.

AERONAUTICAL PROBLEMS

Seconding the motion, Mr. Ronald M. Bell (Unionist) supported the view that the major weapon against noise was a change in the public attitude. He said that, in his opinion, the power-assisted bicycle was the greatest noise menace of modern society and that he was prepared to advocate eccentric remedies. If taxed according to the units of sound they emitted, an unsilenced power-assisted bicycle would pay a road-fund tax of about £80 a year against one of £4 or £5 for a Rolls-Royce motor-car. Then there were the ordinary motor bicycles and noisy private cars. As a result of the ban on the use of motor horns in Paris, traffic there now moved more freely and the number of casualties and injuries had been immediately and dramatically reduced on its introduction.

Not only were aircraft a very great source of noise by volume, they had a disproportionate effect. Their noise penetrated everywhere and continued at night and during week-ends when so many other noises ceased. Research undoubtedly had a large part to play but the £100,000 a year which was being spent hardly seemed to be sufficient. But this was not the only need. Aircraft operators could not reasonably be asked to accept silencers on their machines and mufflers on their jets, with the lower operating efficiency and greater weight which these entailed, unless it were done under some kind of international agreement. The British Government, as that of a heavily-populated country, should be leaders in this field.

Another point with respect to aircraft was that the Act of 1947 provided that operators and manufacturers of aircraft were free from all the restraints placed on ordinary citizens about noise. One could not sue a civil aerodrome, whatever was done there in the matter of noise; nor could manufacturers or repairers of aircraft be proceeded against. It was a striking innovation in the law. Mr. Bell recommended that a definition of noise should be adopted which got away from the words "reasonable and practicable" and came down to the unit of sound, which was the bel.

Another speaker, Mr. R. Gresham Cooke (Unionist), expressed the view that the nature of a noise was more important than its quantity. An irregular or jagged noise was more striking than a rhythmic flow. Noise seemed to be inseparable from movement. The greater the mass moved and the greater the speed, the greater the volume of noise. Much had been done to deaden the noise of internal-combustion engines on the road. What science and industrial effort now had to do was to smooth out the peaks of noise which were so objectionable to the human ear, and, in the aeronautical field, to find solutions which had already been found for the internal-combustion engine.

A number of other speakers took part in the debate and Sir H. Lucas-Tooth, Joint Under-Secretary of State for the Home Office, spoke for the Government. He outlined the various efforts which were being made to find solutions to these problems. The noise of jet engines was about the worst he knew. The problem of reducing it was an intractable one, but research was going on under the Ministry of Supply. Basic research into noise reduction was also being done at the College of Aeronatutics, the National Physical Laboratory, and at the universities of Southampton and Manchester.

Coronary Thrombosis Among Workpeople

The institution of an official inquiry into the incidence of coronary thrombosis, with particular reference to deaths from this disease among workpeople in the engineering industries, was asked for by Mr. Robert Edwards (Labour). The Minister of Health, Mr. Iain Macleod, stated in reply that the General Register Office was already preparing for publication figures showing the incidence of mortality from this condition among occupational groups of the population in the years 1949-53. The Medical Research Council was also studying the matter.

Oil for Electricity Generation

Asked by Mr. Joseph Slater (Labour) how much coal was estimated to have been saved through the appeal to the nationalised electrical industry for the use of oil in place of coal at its generating stations, Mr. L. W. Joynson-Hicks, Parliamentary Secretary to the Ministry of Fuel and Power, said that the first dual-fired station was expected to be running on fuel-oil before the end of the year. Mr. Joynson-Hicks told Major W. W. Hicks Beach (Unionist) that the total route mileage so far planned for the proposed 275 kV grid line was 2,180 miles.

Technical Assistance to Ceylon

During the last twelve months, the United Kingdom Government had spent £140,000 on technical assistance to Ceylon. Mr. Douglas Dodds-Parker, Under-Secretary of State for Commonwealth Relations, informed Mr. R. Graham Page (Unionist) that £30,000 of this total sum was for equipment for training and research institutes. Another main project was a forest research laboratory.

Railway Freight Charges

Mr. Hector Hughes (Labour) inquired if the Secretary of State for Scotland would confer with the Minister of Transport and Civil Aviation and the chairman of the Scottish Tourist Board regarding the equalisation of railway-freight charges into and from Scotland to the south of Great Britain, and for eliminating hardships caused by existing anomalies. Mr. James Stuart replied that, under the Transport Acts, 1947 and 1953, the British Transport Commission's railway-freight charges must be governed by a charges scheme prepared by the Commission and settled by the Transport Tribunal. The Tribunal had already sat in public for 17 days to consider a draft scheme.

Transport Tribunal

The permanent members of the Transport Tribunal are His Honour Hubert Hull, C.B.E. (President), Mr. J. C. Poole, C.B.E., and Mr. A. E. Sewell, M.Inst.T., according to an answer given by the Minister of Transport and Civil Aviation, Mr. John Boyd-Carpenter, to Mr. A. R. Hurd (Unionist). Mr. Hurd was also informed that the Tribunal had sat on 107 days during the two years ended November 30, 1955.

St. Albans By-Pass

Mr. Boyd-Carpenter informed Mr. R. S. Russell (Unionist) that the cost per mile of constructing the proposed St. Albans by-pass, excluding the cost of acquiring the land, would be about £300,000. So far as could be estimated at present land and accommodation works would cost about £500,000, and the roadworks about £4,600,000. Of the last-mentioned amount, about 35 per cent. would represent the cost of materials and 30 per cent. the cost of labour. The balance was the cost of plant, overheads, insurance, and similar items.

Helicopter Development

A series of questions by Mr. Paul Williams (Unionist) to various Departments brought replies that expenditure on the development of helicopters for the Services was borne by the Ministry of Supply. In the case of the Ministry of Transport and Civil Aviation, Mr. Boyd-Carpenter said that, while the development of helicopters, as of other aircraft, was primarily a matter for the Minister of Supply, his Department had been able to assist in the gaining of experience in the problem of helicopter operation for civil purposes by contributions to the cost of the B.E.A. Helicopter Experimental Unit, amounting in all to £602,075. Starting with £28,805 in 1947–48, expenditure rose to £83,390 in 1949–50, and, after declining to lesser amounts in succeeding years, rose to £92,953 in 1954–55. Expenditure to date, for the year 1955–56, amounted to £80,000.

High-Altitude Rocket Project

The Parliamentary Secretary to the Ministry of Supply, Mr. F. J. Erroll, told Captain R. A. Pilkington (Unionist) that the high-altitude rocket project for research in the upper atmosphere was making good progress. Work was being carried out at the Ministry's Royal Aircraft Establishment, which was responsible for the vehicle itself. The design of this was now complete: it would be some 25 ft. long and 17 in. in diameter, and powered by a solid propellant motor.

Six university departments were also collaborating through the Royal Society in the project. Their contribution included the provision of the equipment to take measurements at altitudes ranging from 20 to 120 miles. The first trial firings were expected to take place at Woomera, Australia, in the second half of next year. Mr. Erroll declined to state, without notice, how far British progress in this direction compared with that of other countries.

THE HUMAN ELEMENT

Earnings more important than wages—Top management in American unions—Liberal Party on co-ownership—I.L.O. meeting—British Transport Commission and railway unions—Retired officers go into training.

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Wages and Earnings

The undoubted improvement in the standard of living of the wage earner has owed remarkably little to the increase in wage rates since the war. Since the end of June, 1947, wage rates have increased on the average by 53 per cent. while the cost of living has gone up by 52 per cent. Over the years, therefore, wage rates have just kept level with rising prices. On the other hand, output per worker has advanced by 18 per cent.

Where then has the workers' improvement come from? An article in the latest issue of the London and Cambridge Economic Bulletin indicates in which direction the answer lies. It is earnings that have gone up by 10 per cent. more than wage rates over the years 1948 to 1955. This gap has been caused by two factors. First, there is the increase in the working population. Second, there is the increased amount of overtime, more piecework, and the habit of paying workers at a rate above the minimum standard rate from which the wage rate index is calculated. This being so, the unions in many cases can claim no more than to have held a gradually rising ceiling for workers who have themselves bettered their position by being members of certain groups. Some of these groups would include participants in bonus schemes or in overtime (usually at special rates of pay) and there are of course a large number of benefits for workers under the Welfare State such as the health scheme.

It is wrong to read into these facts that the workers do not need the unions to bargain for wages but they do show that if the unions bargain too often for wage rate increases they will stimulate an inflation with which they can just keep pace—and no more. The wage earners' best friend is still full employment.

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U.S. Trade Union Merger

The merging of the American Federation of Labour and the Congress of Industrial Organisations has brought together under the same leadership trade unions whose membership exceeds 16 million work-people. The differences of dogma which led Mr. John L. Lewis to march out of the A.F.L. 20 years ago and to form the C.I.O. appear to have been ironed out. The joint organisation's slogan is "all trades, all crafts, all colours, all creeds—together" and there is little doubt that the move has considerably strengthened the opposition to the right-wing tendencies that have developed in recent years both in the Republican and Democratic parties.

That differences of opinions will arise in hammering out a common policy is being freely admitted by union leaders. Mr. Lewis has kept his United Mineworkers out of the new organisation, and the leader of the powerful Transport Workers' Union, Mr. Michael Quill, threatened to take his union out on the grounds that the merger did not offer sufficient protection against "racketeering and racialism."

It is difficult to form an opinion at this stage of the likely effects of the merger on the American labour scene. Politically, the power of U.S. trade unions is obviously much increased and could exert a vital influence in the forthcoming Presidential election. But the president of the joint organisation, Mr. George Meaney, although he foresaw that the consolidated unions would play an active political role, said that they would do so without subscribing to one party or the other. Industrially it is doubtful whether any radical change in the well-tried practice of trade union contracts with individual companies will take place.

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Owner-Workers

The Liberal Party council have before them a report on co-ownership in industry, which they were due to discuss last week-end. A year ago at the party conference at Buxton a report from their co-ownership committee recommending that joint stock companies should be compelled to adopt a "single uniform detailed scheme" was rejected by a majority of the delegates. The committee's new report recommends the party executive to reconstitute the committee as a standing committee to continue their investigation, watch developments and advise the party on the most effective ways of providing co-ownership in "the constantly changing circumstances of to-day."

The report points out that an increasing number of firms have adopted schemes embodying some of the principles of co-ownership, and concludes that "the tide seems to have changed in this direction." There is little doubt that the large companies in this country, who have a major problem of recruitment and training—a problem which is likely to be considerably magnified during the next few years by the adoption of automatic production techniques—must give adequate incentives for young people to join them and stay with them. There is also the need for high morale, generally recognised at present as the product mainly of good leadership but obviously affected by such considerations as "the feeling to belong" to the firm, and dignity in work. Co-ownership may develop as the answer to the relative failure in our time of bonus incentives, piece-rate systems and the like, the effectiveness of which must grow less as machine speeds and process flow become the main factors in efficient production. Profit-sharing is far from being accepted as an alternative to direct financial incentives related to individual or small group effort. It is as well to remember that in a period of radical change in the methods of production a corresponding change is likely to take place in the methods of personnel management. In this case the pride of ownership and the financial rewards it should bring could revolutionise labour relations and the attitudes of the unions to production problems.

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Truly International

The 38th session of the International Labour Conference held last June went off remarkably well, according to the U.K. Government delegates whose report has just been published by the Stationery Office (Cmd. 9629). The feature of the session was that the presence of delegates from the Soviet Union and other Soviet bloc countries "did not prevent the Conference from getting on with its work and producing useful results." Among its achievements were the adoption of a convention concerning the abolition of penal sanctions for breaches of contract of employment by indigenous workers and two recommendations, concerning vocational rehabilitation of the disabled and the protection of migrant workers in underdeveloped countries and territories.

The Minister of Labour and National Service, who addressed the Conference, repeated to his international audience his oft-stated convictions that the promotion of freedom and dignity in work had in Britain replaced the carrot and stick incentives of pre-war days, and that the main object of a human-relations policy should be the creation of confidence between management and workpeople. Such candid words must have had a strange ring in the ears of the employers' representatives from the Soviet countries whose own difficulties in this field are frequently commented upon in their Press.

The future of the I.L.O. seems to hang on a report which is being prepared by an independent fact-finding committee set up by the governing body of the Organisation to inquire into the extent to which employers and workers' organisations in member states are genuinely free from government domination and control. The conclusion that such an inquiry might reach in the present circumstances could well make the 38th session one of the last, as well as being the first, at which the deliberations of East and West on labour problems produced useful results. If so, it would be a pity, for the I.L.O. is a lone but worthy champion of the exploited, whether in Africa or Siberia.

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Railwaymen's Claims Rejected

The British Transport Commission have rejected claims from the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs Association for improved conditions, which included a shorter working week, higher overtime and night-duty pay, longer holidays and several other improvements. The B.T.C.'s grounds for rejecting the claims were that they could not be met with the present shortage of manpower and that the cost, estimated at £55 million a year, was too high. There is in addition a claim for higher basic rates which the N.U.R. and T.S.S.A. are to present this week, which if granted would cost an additional £30 million a year.

That a difficult situation would arise has been clearly foreseen by all concerned for some time, and few could have expected the B.T.C. to concede all demands made upon them. Their agreement to consider further a request for payment during absence for sickness or accident is evidence enough that they are prepared to go some of the way to meet the unions' wishes where a strong case exists. Future developments will depend very largely on the attitudes of the unions concerned. They may decide to pursue their claims through the Railway Staff National Council and subsequently, if no satisfaction can be obtained, they can refer them to arbitration by the Railway Staff National Tribunal. It would be unrealistic, however, to expect the B.T.C. to fall in line with the unions' wishes until the railway modernisation programme has yielded economies to offset mounting losses.

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Jobs for Retired Officers

Retired senior officers from the armed services and the Colonial Service find it more difficult than ever before to find congenial employment. This is a very paradoxical situation. The country is short of first-rate administrators and technicians and men such as these have a wide experience in management and responsibility.

Why should this be so? It is essentially a problem of modern industry. The more highly organised industry becomes on the side of management, with its carefully arranged grades of seniority and carefully calculated pensions schemes, the more difficult is it to bring in a middle-aged outsider of merit. Again, so great is the rate of technical change that even technical men newly retired find it difficult to get a job unless they can first go through a refresher course.

The Federation of British Industries have now started a scheme for such men. An advisory council has been set up, and also industrial selection panels. Officials who are approved by the panels may go forward to the Industrial Appreciation Course. The courses have already begun. It should not be beyond the wit of industry to find responsible work for men who take the trouble (pride may have to be swallowed in the process) to undergo such a refresher. The F.B.I. do not undertake to find jobs at the end of the course, but they are to be congratulated for tackling one side of the problem. The rest is up to firms in industry.